NASA CR 134760

(1)

VOLUME II

LIGHTWEIGHT VACUUM JACKET FOR CRYOGENIC INSULATION

APPENDICIES TO FINAL REPORT

By
D. L. Barclay, J. E. Bell, E. W. Brogen & J. W. Straayer

BOEING AEROSPACE COMPANY

Prepared for
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
NASA Lewis Research Center

CONTRACT NAS3-15848

J. R. Barber, Project Manager

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
NASA CR 134760		

4. Title and Subtitle
VACUUM JACKET FOR CRYOGENIC INSULATION

5. Report Date
April 1975

6. Performing Organization Code

7. Author(s)
D. L. BARCLAY, J. E. BELL, E. W. BROGREN, & J. W. STRAAYER

8. Performing Organization Report No.
D180-18476-2

9. Performing Organization Name and Address
BOEING AEROSPACE COMPANY
(A Division of The Boeing Company)
P.O. BOX 3999 SEATTLE, WASHINGTON 98124

10. Work Unit No.

11. Contract or Grant No.
NAS3-15848

12. Sponsoring Agency Name and Address
National Aeronautics & Space Administration
Lewis Research Center

13. Type of Report and Period Covered
Final Contractor Report

14. Sponsoring Agency Code

15. Supplementary Notes

J. R. BARBER, PROJECT MANAGER

16. Abstract

This program demonstrated the feasibility of producing a Lightweight Vacuum Jacket using state-of-the-art technology and materials. Design and analytical studies were made on a full scale, i.e., 4.57 m (15 ft.) inside diameter with a volume of 65.1 m^3 (2300 $ft.^3$), oms fuel (LH_2) tank. Preliminary design details were completed for the tank assembly which included an optimized vacuum jacket and MLI system. A half scale LH_2 test model was designed and fabricated. A force/stiffness (F/S) proof test was conducted on the vacuum jacket. The vacuum jacket designed and fabricated on this program achieved a vacuum leak rate of 1×10^{-5} atmosphere ml of helium per second, sustained approximately 1500 hours of vacuum pressure and experienced 29 vacuum pressure cycles prior to failure.

* KEY WORDS

Evaluated MLI System, Vacuum Jacket
Space Shuttle Orbiter
Oms Fuel (LH_2) Tank
Force/Stiffness (F/S) Proof Test
Vacuum Annulus Preconditioning

17. Key Words (Suggested by Author(s))	18. Distribution Statement
*	UNCLASSIFIED-UNLIMITED

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price*
Unclassified	Unclassified		$3.00

* For sale by the National Technical Information Service, Springfield, Virginia 22151

NASA-C-168 (Rev. 6-71)

TABLE OF CONTENTS

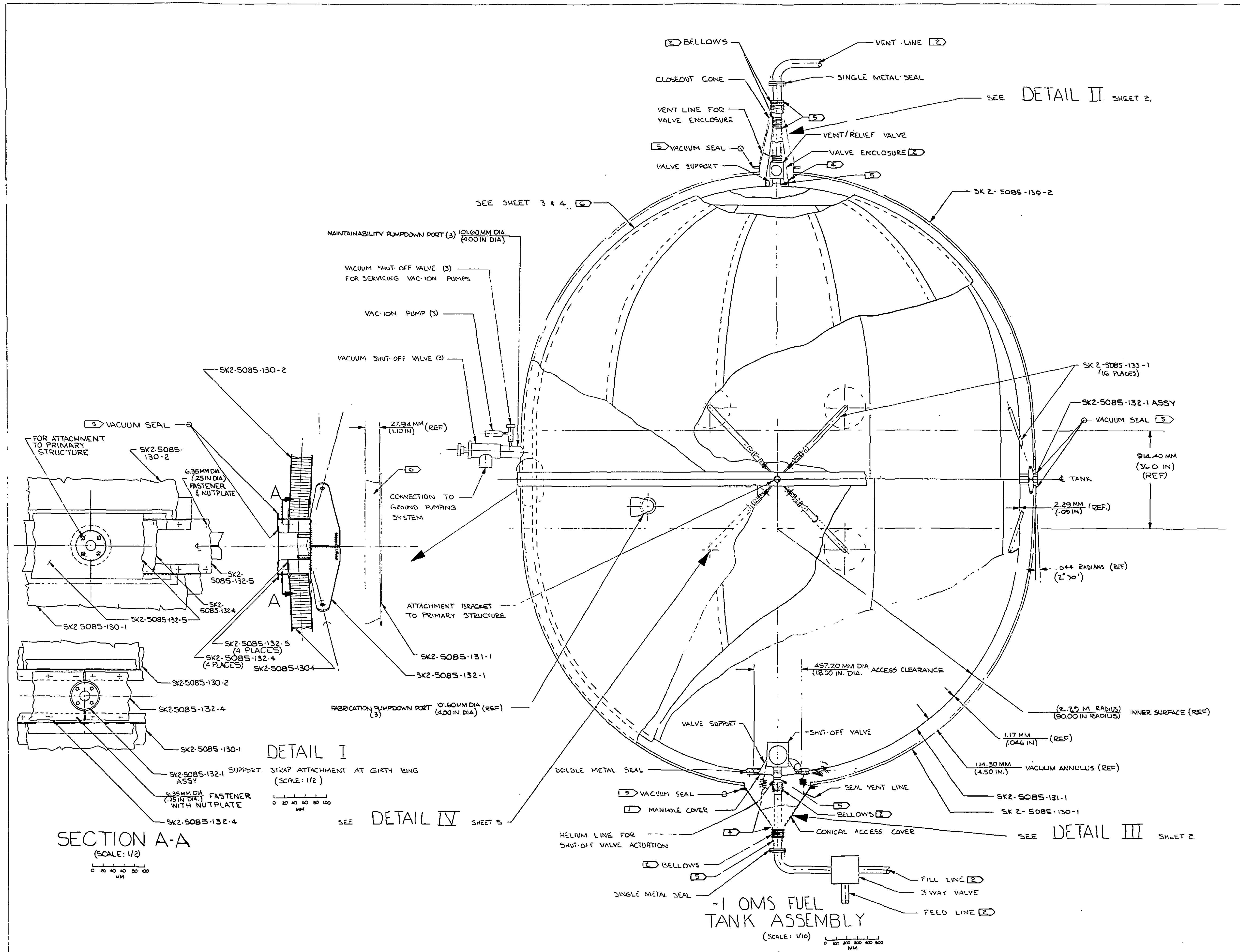
INTRODUCTION

This is a companion document to Volume I, NASA CR 134759, "Final Report." The appendices contained herein supplement the technical discussion in that document.

APPENDIX A

OMS FUEL TANK PRELIMINARY DESIGN DRAWINGS

REVISIONS	
9/11/72	10/10/72
11/10/72	12/10/72
1/10/73	



ASSEMBLY AND QUALIFICATION PROCEDURES

1.0 DETAILS AND SUBASSEMBLIES
- a) PRESSURE VESSEL WELD ASSEMBLY. LN_2 COLD SHOCK, PROOF PRESSURE TEST, AND HELIUM LEAK CHECK
- b) SUPPORT STRAP DETAILS
- c) GIRTH RING WELD ASSEMBLY AND MACHINING
- d) VACUUM JACKET SUBASSEMBLIES
- e) MLI BLANKET SUBASSEMBLIES
- f) MANHOLE COVER ASSEMBLY (COVER, SHUT-OFF VALVE, AND FEED LINE)

2.0 ASSEMBLE PRESSURE VESSEL, SUPPORT STRAPS, GIRTH RING, VENT LINE, AND VENT RELIEF VALVE.

3.0 INSTALL MLI BLANKET ON PRESSURE VESSEL. INSULATE SUPPORT STRAPS AND VENT LINE

4.0 INSTALL VACUUM JACKET SUBASSEMBLIES. SEAL JOINTS AT GIRTH RING AND VENT LINE OUTLET FOR VACUUM.

5.0 INSTALL MANHOLE COVER, FEED LINE, AND SEAL VENT LINE. INSULATE THE AREA. INSTALL VACUUM JACKET COVER. SEAL JACKET COVER AND FEED LINE OUTLET FOR VACUUM.

6.0 HELIUM LEAK CHECK ASSEMBLY. REPAIR AS NECESSARY. PUMPDOWN VACUUM ANNULUS TO 5×10^{-5} TORR. CONDUCT VACUUM DECAY TEST. PRECONDITION WITH HEAT AND VACUUM PUMPING AS NECESSARY TO REACH REQUIRE DECAY RATE. PINCH OFF AND SEAL THE THREE FABRICATION PUMPDOWN PORTS. CLOSE VACUUM VALVES ON THE MAINTAINABILITY PUMPDOWN PORTS.

7.0 CONDUCT BOIL-OFF TEST.

NOTES

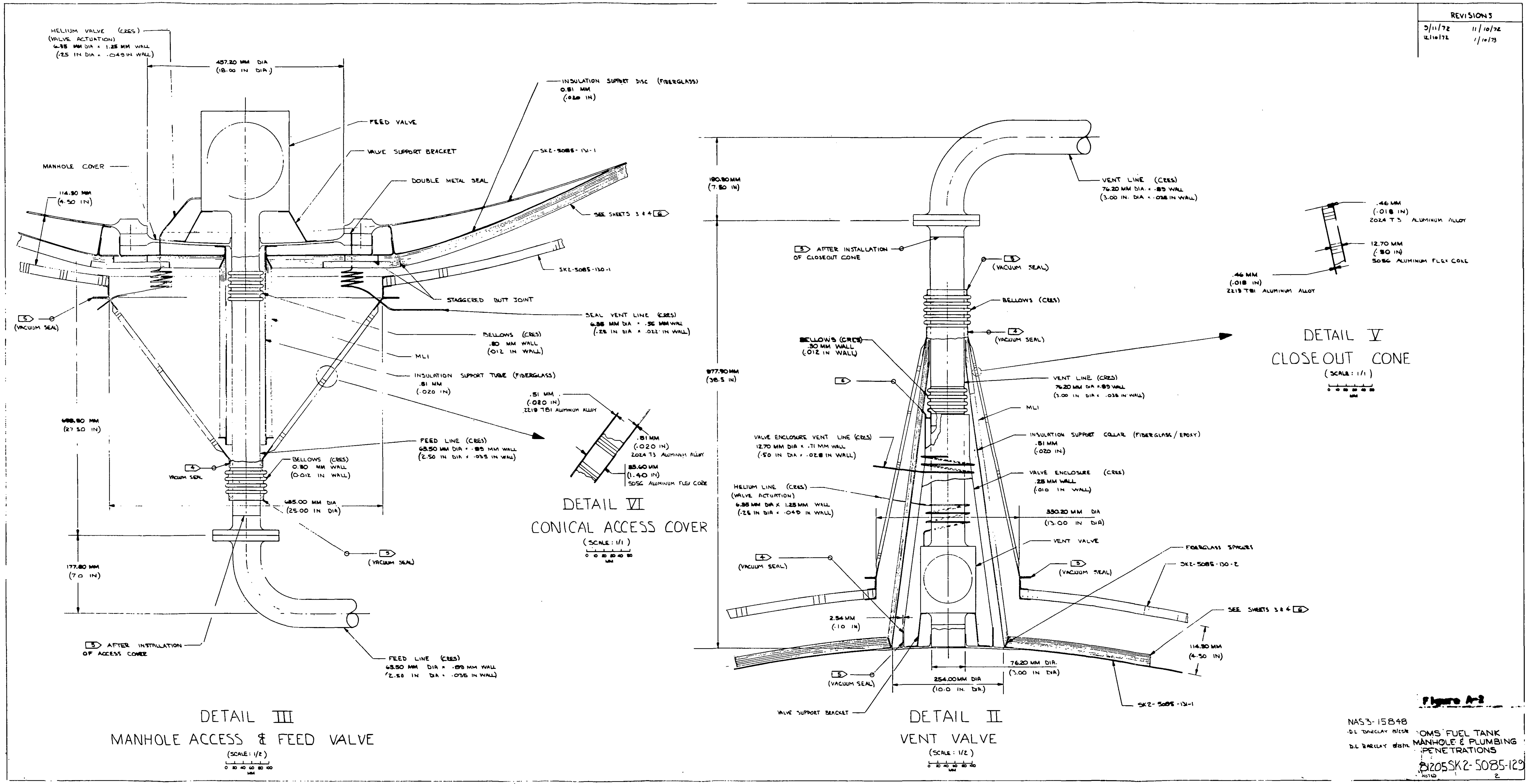
1. ALUMINUM ALLOY 2219-T81
2. STAINLESS STEEL
4. DIFFUSION BOND
5. WELD
6. MULTI LAYER INSULATION (MLI)
   - a) ALUMINIZED MYLAR (.15 MIL)/DACRON NET (B4A) - 2.95 LAYERS/MM (75 LAYERS/INCH)
   - b) OUTER 2.54MM (.10 IN) LAYER - ALUMINIZED KAPTON (0.30 MIL)/DACRON NET (B4A) - 2.95 LAYERS/MM (75 LAYER/INCH)
7. HOOK & PILE FASTENER - VELCRO OR EQUIVALENT
8. DACRON THREAD
9. ZYTEL 103 HS1-L NYLON RESIN

Figure A-1

OMS FUEL TANK ASSEMBLY

81205 SK2-5085-129

2



REVISIONS
5/11/72 11/10/72
12/10/72 1/10/73
HELIUM VALVE (CRES)
(VALVE ACTUATION)
6.35 MM DIA × 1.25 MM WALL
(.25 IN DIA × .049 IN WALL)
457.20 MM DIA
(18.00 IN DIA)
INSULATION SUPPORT DISC (FIBERGLASS)
0.51 MM
(.020 IN)
FEED VALVE
VALVE SUPPORT BRACKET
SK2-5085-131-1
MANHOLE COVER
DOUBLE METAL SEAL
114.30 MM
(4.50 IN)
SEE SHEETS 3 & 4 6
SK2-5085-130-1
STAGGERED BUTT JOINT
5
(VACUUM SEAL)
SEAL VENT LINE (CRES)
6.35 MM DIA × .56 MM WALL
(.25 IN DIA × .022 IN WALL)
BELLOWS (CRES)
.30 MM WALL
(.012 IN WALL)
MLI
INSULATION SUPPORT TUBE (FIBERGLASS)
.81 MM
(.020 IN)
.51 MM
(.020 IN)
2219 T81 ALUMINUM ALLOY
698.50 MM
(27.50 IN)
.51 MM
(.020 IN)
2024 T3 ALUMINUM ALLOY
35.60 MM
(1.40 IN)
5056 ALUMINUM FLEX CORE
FEED LINE (CRES)
63.50 MM DIA × .89 MM WALL
(2.50 IN DIA × .035 IN WALL)
4
VACUUM SEAL
BELLOWS (CRES)
0.30 MM WALL
(0.012 IN WALL)
635.00 MM DIA
(25.00 IN DIA)
DETAIL VI
CONICAL ACCESS COVER
(SCALE: 1/1)
177.80 MM
(7.0 IN)
5
(VACUUM SEAL)
5 AFTER INSTALLATION
OF ACCESS COVER
FEED LINE (CRES)
63.50 MM DIA × .89 MM WALL
(2.50 IN DIA × .035 IN WALL)
DETAIL III
MANHOLE ACCESS & FEED VALVE
(SCALE: 1/2)
190.50 MM
(7.50 IN)
VENT LINE (CRES)
76.20 MM DIA × .89 MM WALL
(3.00 IN DIA × .035 IN WALL)
.46 MM
(.018 IN)
2024 T3 ALUMINUM ALLOY
12.70 MM
(.50 IN)
5056 ALUMINUM FLEX CORE
.46 MM
(.018 IN)
2219 T81 ALUMINUM ALLOY
5 AFTER INSTALLATION
OF CLOSEOUT CONE
5
(VACUUM SEAL)
BELLOWS (CRES)
4
(VACUUM SEAL)
BELLOWS (CRES)
.30 MM WALL
(.012 IN WALL)
DETAIL V
CLOSEOUT CONE
(SCALE: 1/1)
977.90 MM
(38.5 IN)
6
VENT LINE (CRES)
76.20 MM DIA × .89 WALL
(3.00 IN DIA × .035 IN WALL)
MLI
VALVE ENCLOSURE VENT LINE (CRES)
12.70 MM DIA × .71 MM WALL
(.50 IN DIA × .028 IN WALL)
INSULATION SUPPORT COLLAR (FIBERGLASS / EPOXY)
.81 MM
(.020 IN)
VALVE ENCLOSURE (CRES)
.25 MM WALL
(.010 IN WALL)
HELIUM LINE (CRES)
(VALVE ACTUATION)
6.35 MM DIA × 1.25 MM WALL
(.25 IN DIA × .049 IN WALL)
330.20 MM DIA
(13.00 IN DIA)
VENT VALVE
4
(VACUUM SEAL)
FIBERGLASS SPACERS
5
(VACUUM SEAL)
SK2-5085-130-2
SEE SHEETS 3 & 4 6
2.54 MM
(.10 IN)
114.30 MM
(4.50 IN)
5
(VACUUM SEAL)
76.20 MM DIA
(3.00 IN DIA)
254.00 MM DIA
(10.0 IN DIA)
SK2-5085-131-1
VALVE SUPPORT BRACKET
DETAIL II
VENT VALVE
(SCALE: 1/2)
Figure A-3
NAS3-15848
D.L. BARCLAY
D.L. BARCLAY
OMS FUEL TANK
MANHOLE & PLUMBING
PENETRATIONS
81205 SK2-5085-129
NOTED 2

3

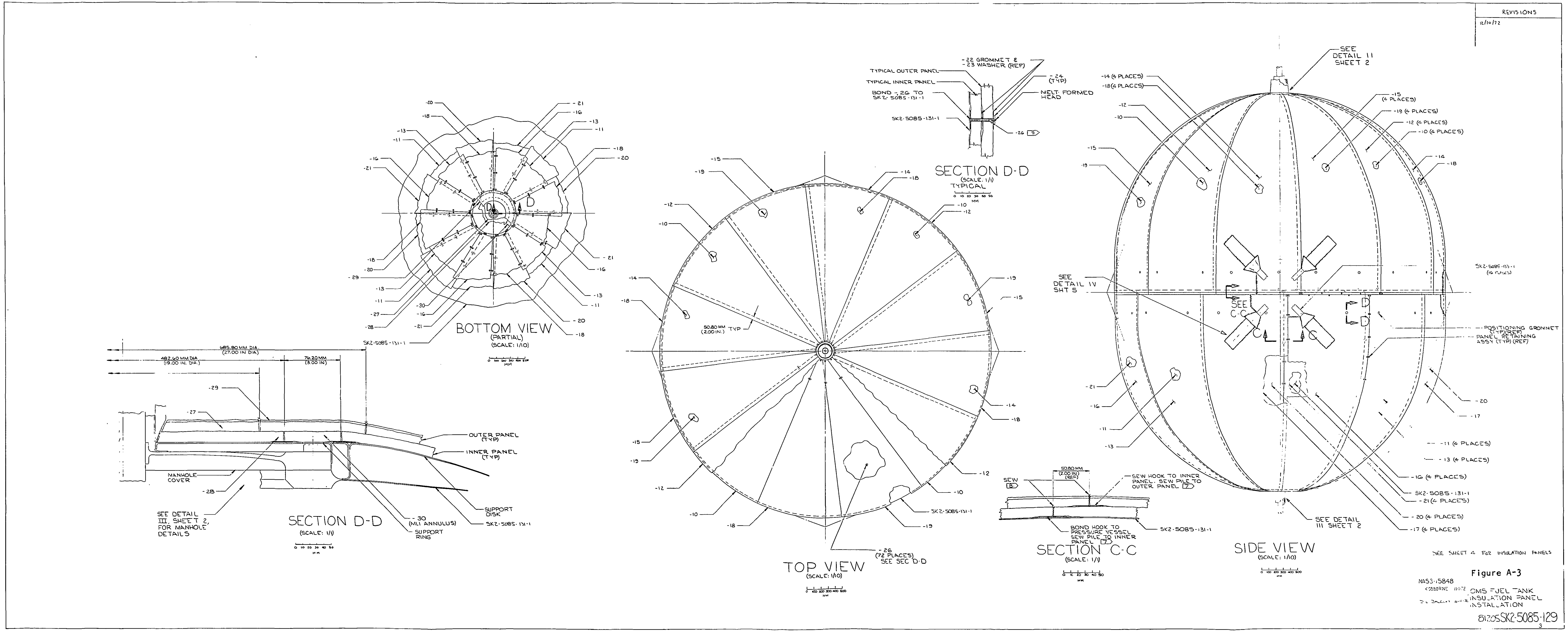

REVISIONS
BOTTOM VIEW
(PARTIAL)
(SCALE: 1/10)
SECTION D-D
(SCALE: 1/1)
TYPICAL
TYPICAL OUTER PANEL
TYPICAL INNER PANEL
BOND -26 TO SK2-5085-131-1
-22 GROMMET & -23 WASHER (REF)
MELT FORMED HEAD
TOP VIEW
(SCALE: 1/10)
50.80 MM (2.00 IN.) TYP
-26 (72 PLACES) SEE SEC D-D
SIDE VIEW
(SCALE: 1/10)
SEE DETAIL II SHEET 2
SEE DETAIL IV SHT 5
SEE DETAIL III SHEET 2
POSITIONING GROMMET TYP (REF)
PANEL RETAINING ASSY (TYP) (REF)
SECTION C-C
(SCALE: 1/1)
SEW HOOK TO INNER PANEL. SEW PILE TO OUTER PANEL
BOND HOOK TO PRESSURE VESSEL SEW PILE TO INNER PANEL
685.80 MM DIA (27.00 IN DIA)
482.60 MM DIA (19.00 IN. DIA.)
76.20 MM (3.00 IN)
OUTER PANEL (TYP)
INNER PANEL (TYP)
MANHOLE COVER
SUPPORT DISK
SUPPORT RING
-30 (MLI ANNULUS)
SEE DETAIL III, SHEET 2, FOR MANHOLE DETAILS
SK2-5085-131-1
SEE SHEET 4 FOR INSULATION PANELS
NAS3-15848
OMS FUEL TANK INSULATION PANEL INSTALLATION
81205 SK2-5085-129

Figure A-3

4

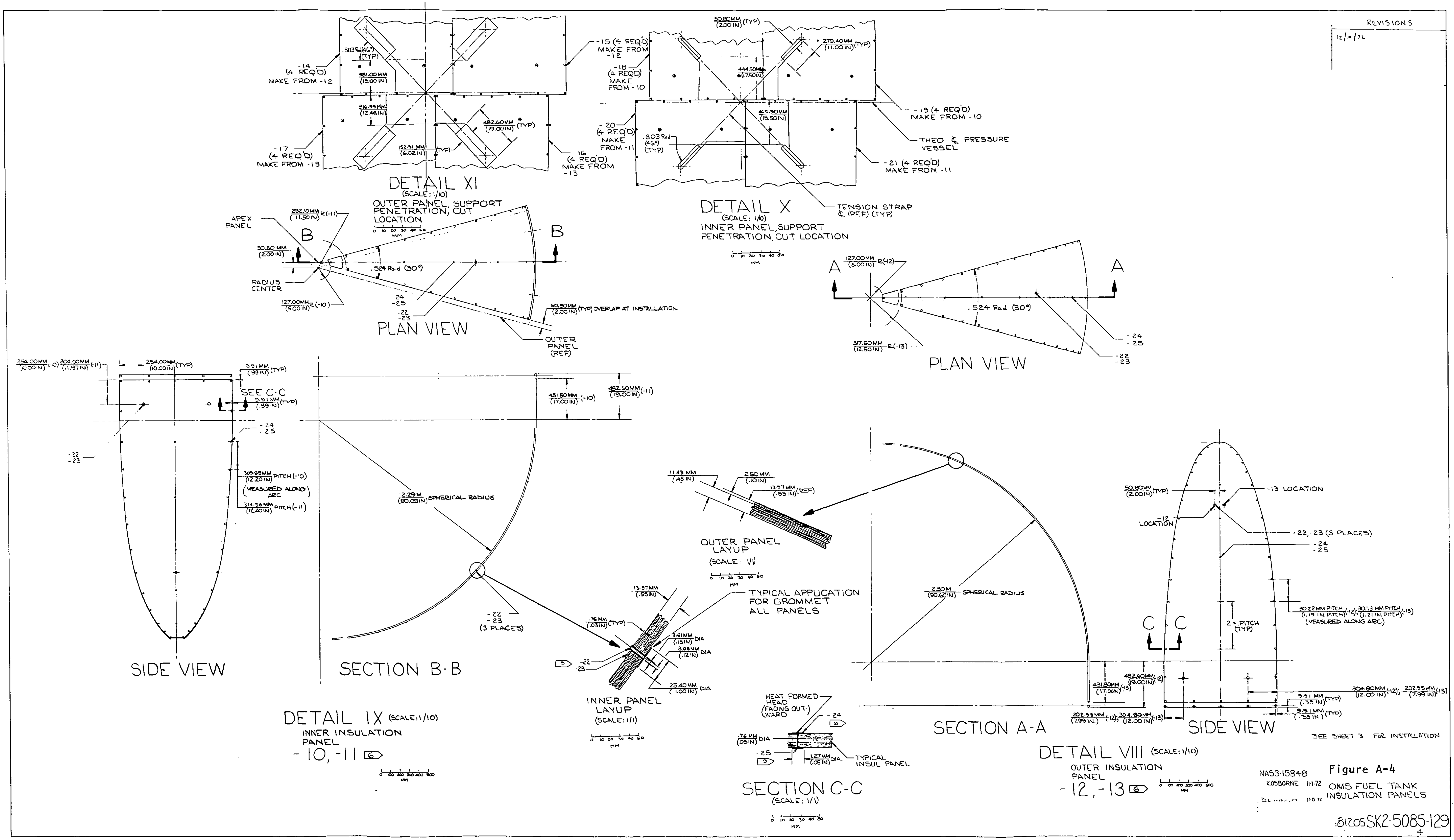
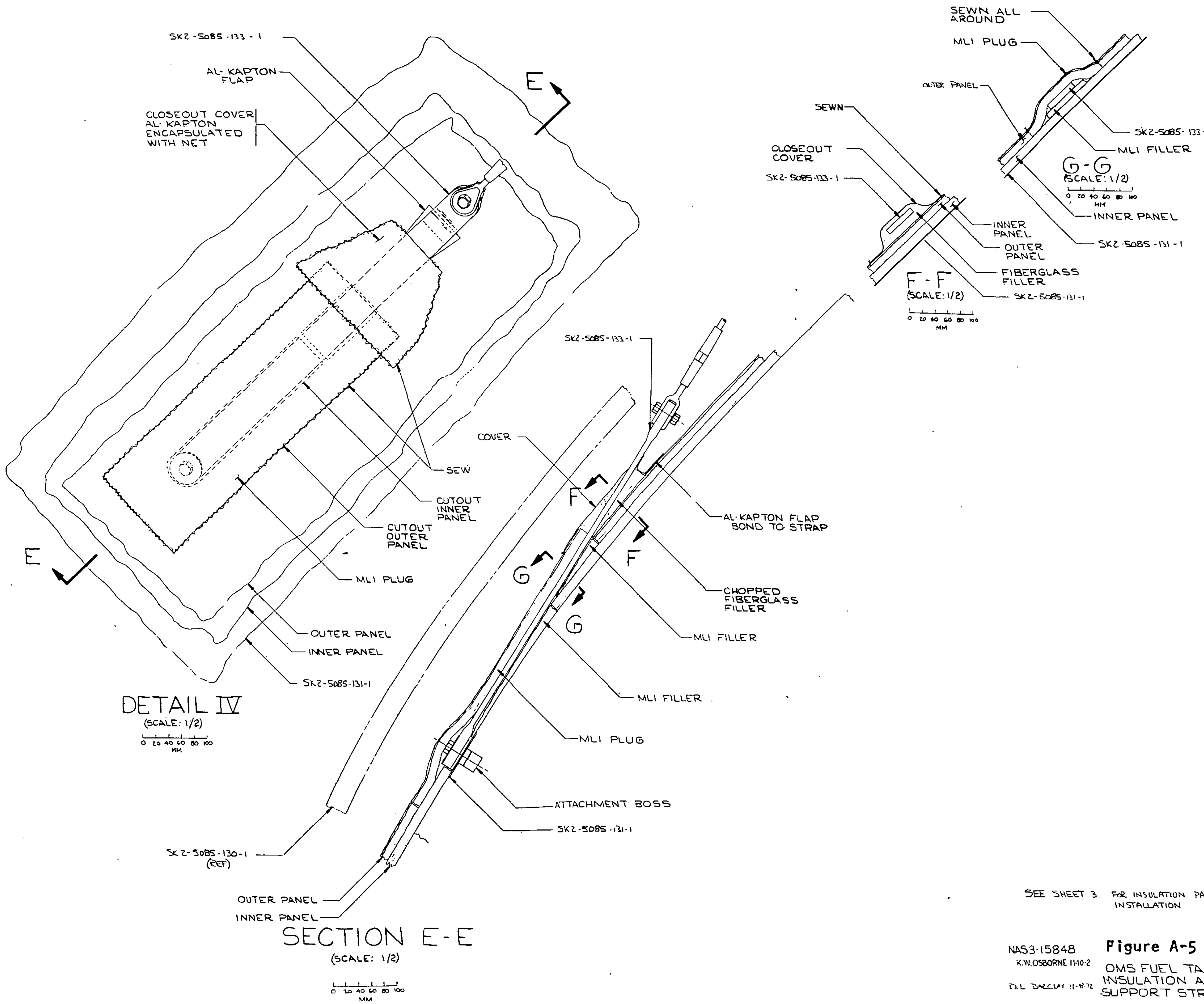


Figure A-4 OMS FUEL TANK INSULATION PANELS

REVISIONS



SEE SHEET 3 FOR INSULATION PANEL INSTALLATION

NAS3-15848
K.W. OSBORNE 11-10-2
D.L. BARCLAY 11-8-72

Figure A-5
OMS FUEL TANK INSULATION AT SUPPORT STRAP

81205 SK2-5085-129
5

SK2-5085-129 SH 2

PARTS LIST	THE BOEING COMPANY CORPORATE OFFICES SEATTLE, WASHINGTON 98124	CONTRACT NUMBER NAS 3-15848	CODE IDENT NUMBER 81205	PL SK2-5085-130	SHEET 1	REV LTR

ADDITIONAL QTY REQD COLUMNS MAY BE SHOWN ON CONTINUATION SHEET IMMEDIATELY FOLLOWING

EAMR NUMBER	FIND NUMBER	QTY REQD	QTY REQD	QTY REQD	QTY REQD	QTY REQD	QTY REQD	QTY REQD -2	QTY REQD -1	CODE IDENT NUMBER	PART OR IDENTIFYING NUMBER	NOMENCLATURE OR DESCRIPTION	ZONE	MATERIAL AND SPECIFICATION	TRACE	NOTES	REV LTR
									—		-1	HEAD ASSEMBLY					
								—			-2	HEAD ASSEMBLY					
								1	1		-3	CORE		2			
								-	3		-4	GORE-INNER		1			
								3	—		-5	GORE-INNER					
								-	5		-6	GORE-INNER					
								5	-		-7	GORE-INNER					
								-	3		-8	GORE-OUTER					
								3	-		-9	GORE-OUTER					
								-	5		-10	GORE-OUTER					
								5	-		-11	GORE-OUTER					
								-	1		-12	ANNULUS					
								-	1		-13	ANNULUS					
								1	-		-14	ANNULUS					
								1	-		-15	ANNULUS					
								-	8		-16	FILLER					
								8	-		-17	FILLER		1			
								-	1		-18	FLANGE		7			
								1	-		-19	FLANGE		7			
								-	8		-20	STRIP-INNER		1			
								8	-		-21	STRIP-INNER		1			

FIGURE: A-7

PARTS LIST	THE BOEING COMPANY CORPORATE OFFICES SEATTLE, WASHINGTON 98124	CONTRACT NUMBER NAS3-15848	CODE IDENT NUMBER 81205	PL SK2-5080-130	SHEET 2	REV LTR

EAMR NUMBER	FIND NUMBER	QTY REQD	QTY REQD	QTY REQD	QTY REQD	QTY REQD -34	QTY REQD -27	QTY REQD -2	QTY REQD -1	CODE IDENT NUMBER	PART OR IDENTIFYING NUMBER	NOMENCLATURE OR DESCRIPTION	ZONE	MATERIAL AND SPECIFICATION	TRACE	NOTES	REV LTR
								-	8		-22	STRIP-OUTER		1			
								8	-		-23	STRIP-OUTER					
								-	8		-24	STRIP-EXTERNAL					
								8	-		-25	STRIP-EXTERNAL		1			
							-	3	3		-27	TUBE ASSY		10			
							1	-	-		-28	TUBE		7			
							1	-	-		-29	FLANGE		7			
								3	3		-30	COLLAR		1			
								8	8		-31	DOUBLER		1			
								-	3		-32	ANGLE-CLOSEOUT		1			
								3	-		-33	ANGLE-CLOSEOUT		1			
								1	1		-34	RING ASSY		10			
						3	-	-	-		-35	SEGMENT		7			
								8	8		-36	DOUBLER		1			
								8	8		-38	FILLER		1			
								-	8		-39	FILLER		1			
								8	-		-40	FILLER		1			
											464HE1032-16	INSERT, POTTED					
											-41						

ADDITIONAL QTY REQD COLUMNS MAY BE SHOWN ON CONTINUATION SHEET IMMEDIATELY FOLLOWING

U3 4603 3050 ORIG. 1/71

REV LTR

ASSEMBLY AND QUALIFICATION PROCEDURES
-1 & -2, HEAD ASSEMBLY

1.0 ASSEMBLE INNER GORES -4,-5,-6,-7; INNER STRIPS -20,-21; CLOSE OUT FLANGE -18,-19; ANNULI -12,-13,-14,-15; FILLERS -16,-17 & -38; TUBE ASSY -27; GIRTH RING ASSY -34. PER 8

2.0 HELIUM LEAK CHECK INNER SKIN ASSY AT 1.333 cN/m^2 (1×10^{-5} TORR)

3.0 FILL GORE SEAM GAPS FLUSH WITH XA3919 (3M Co)

4.0 BOND STRIPS -22,-23; -36 DOUBLERS PER 8

5.0 HELIUM LEAK CHECK (2.0)

6.0 APPLY METLBOND 329 TO THE OUTER SURFACE OF THE INNER SKIN PER 4 ASSEMBLE INNER ANGLE SEG -36; CORE -3; APPLY METLBOND 329 TO -36 INNER ANGLE SEG FAYING SURFACES & CONTACT SURFACES WITH -3. WIRE CORE (-3) TOGETHER AT SEAMS. SPLICE CORE WITH 5 THEN BOND PER 4.

7.0 HELIUM LEAK CHECK (2.0)

8.0 REINFORCE GIRTH CORE WITH 5 COMPLETELY AROUND CIRCUMFERENCE AS SHOWN.

9.0 APPLY METLBOND 329 TO THE INNER SURFACE OF THE OUTER SKIN GORES -8, -9,-10,-11; OUTER STRIPS -24 -25, ; APPLY TO -31 DOUBLERS, INNER CONTACT SURFACES. PER 4 ASSEMBLE TO CORE THEN BOND PER 4.

10.0 HELIUM LEAK CHECK (2.0)

FIGURE: A-8

SIZE	CODE IDENT NO.	
B	81205	SK2-5085-130
SCALE —		SHEET 3 OF 5

1 2024-T81 ALUM PER QQ-A-250/4 3

2 FLEX-CORE 5056/F40-.0014, 33.6 kg/m^3, (2.1 # FT^3) ALUMINUM HONEYCOMB- HEXCEL PRODUCTS INC - SPLICE CORE GORES WITH 5

3 CLEAN PER BAC 5514

4 CLEAN & BOND PER DOC D6-23841 TN. METLBOND 329 ADHESIVE (NARMCO MATERIALS DIV., WHITTACER CORP.) SHALL BE APPLIED TO FAYING SURFACES NOTED:

5 STRUCTURAL FOAMING ADHESIVE PER BAC 5-90, TYPE 2, CLASS 350, GRADE 50.

6 ALL RAW MATERIALS, SUBASSEMBLIES & ASSEMBLYS SHALL BE PROTECTED FROM OIL & PARTICLE CONTAMINATION. ASSEMBLY SHALL BE DONE IN A DUST FREE ROOM.

7 ALUMINUM 2219-T6 OR T62, PER BMS7-110B OR BMS7-108

8 BOND WITH XA3919 (3MCo) APPLY BY BRUSH COATING BOTH SURFACES. AIR DRY THE SURFACES FOR 15 MIN. FOLLOWED BY A 45 MIN. DRYING CYCLE AT 380°K (225°F), CURE BOND AT 450°K (350°F) FOR 3600 SEC AT 344.74 kN/m^2 (50 PSI).

9 DEVIATION FROM RADIUS ± .051 cm (.02 IN) PROVIDED THE DISCONTINUITIES DO NOT EXCEED ±.051 cm IN 25.4 cm (10.0 IN) LENGTH IN ANY DIRECTION ALONG THE SURFACE

10 BMS 5-25 GRADE 3, APPLY PER BAC 5514-590.

11 FUSION WELD PER BAC 5935, CLASS A. EXCEPT RADIOGRAPHIC INSPECTION IS WAIVED. PENETRANT INSPECT PER BAC 5423. HELIUM LEAK CHECK 1.333 cN/m^2 (1×10^{-5} TORR)

FIGURE: A-9

SIZE	CODE IDENT NO.	
B	81205	SK2-5085-130
SCALE		SHEET 4 OF 5


SECTION B2
(SCALE: 1/1)
SECTION C4
(SCALE: 1/1)
SKIN GAGES ARE NOT SHOWN TO SCALE
BOTTOM VIEW
(SCALE: 1/10)
SIDE VIEW
(SCALE: 1/10)
-1 ASSEMBLY SHOWN
-2 ASSEMBLY SIMILAR
TOP VIEW
(SCALE: 1/10)
SECTION C6
(SCALE: 1/1)
SECTION 1B2
(SCALE: 1/1)
NOTE: ALL INTERNAL STRIP DETAILS ROTATED INTO VIEW.
DETAIL B4
(SCALE: 1/1)
CONTOUR GEOMETRY
THEORETICAL ℄ VACUUM JACKET
HEMISPHERE ℄
INSIDE CONTOUR
TANGENT
VERTICAL LINE
THE BOEING COMPANY
NAS3-15848
VACUUM JACKET
-EAD ASSEMBLY-
OMS FUEL TANK
SK2-5085-130

Figure A-10

DASH NO	REINFORCEMENT LOCATION 'A'	'B'	'C'	QTY REQD
-2	NO REINFORCEMENT			4
-3	–	–	X	4
-4	X	–	–	4
-5	–	X	–	4

SEE SECTION C-C

Figure A-11

2-5520

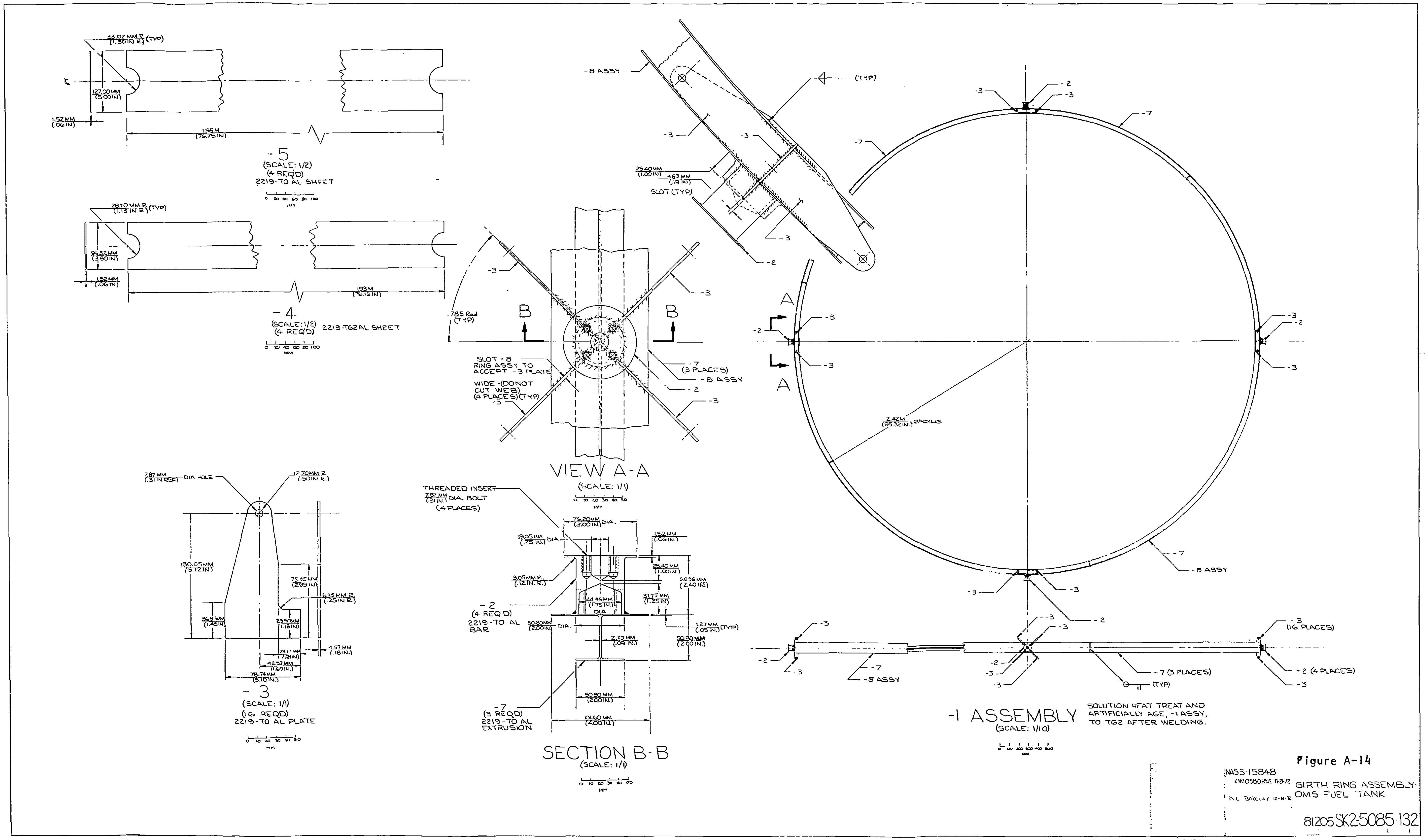


Figure A-14

NAS3-15848
GIRTH RING ASSEMBLY-OMS FUEL TANK

81205 SK2-5085-132

2-5520

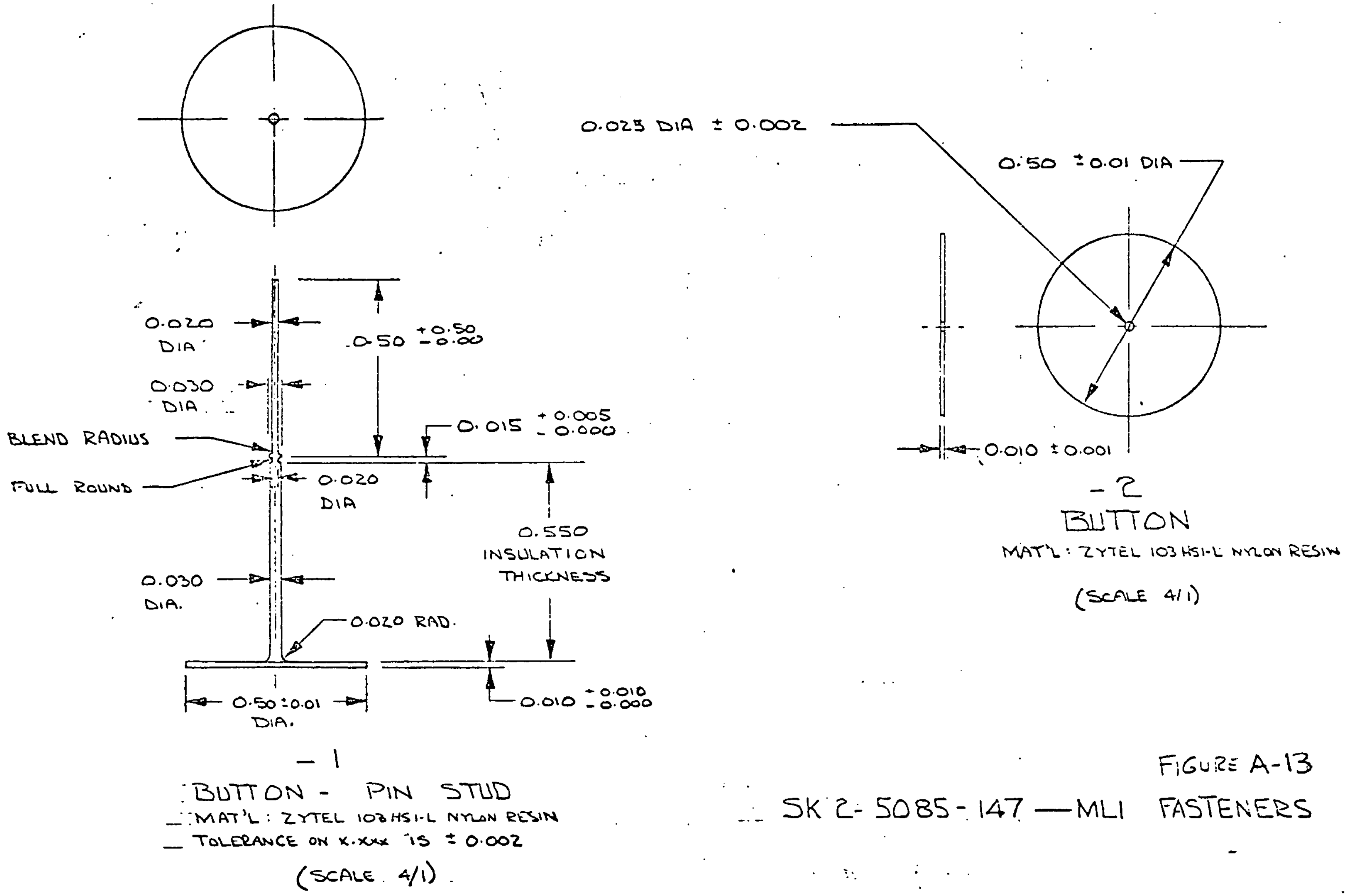
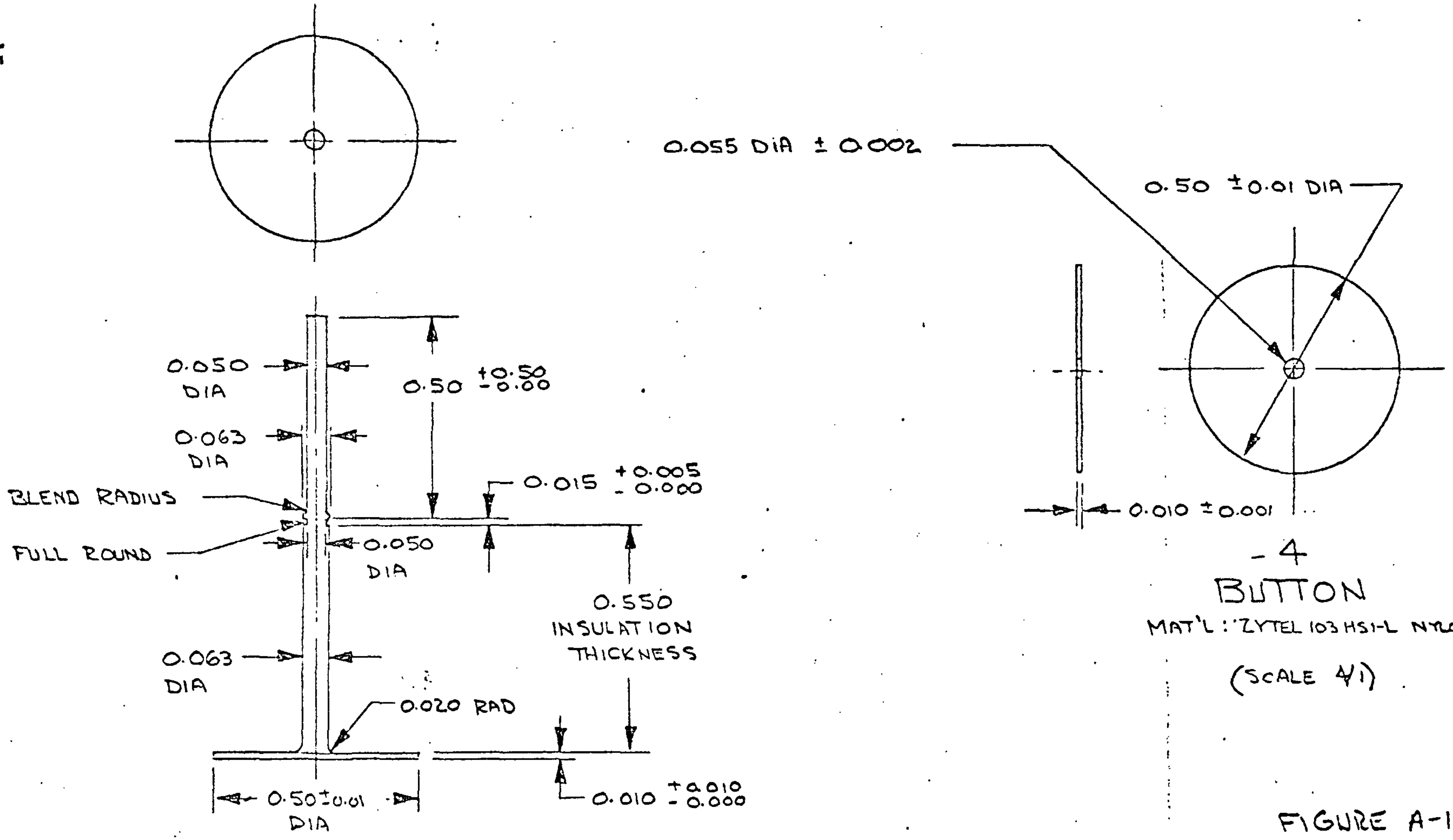


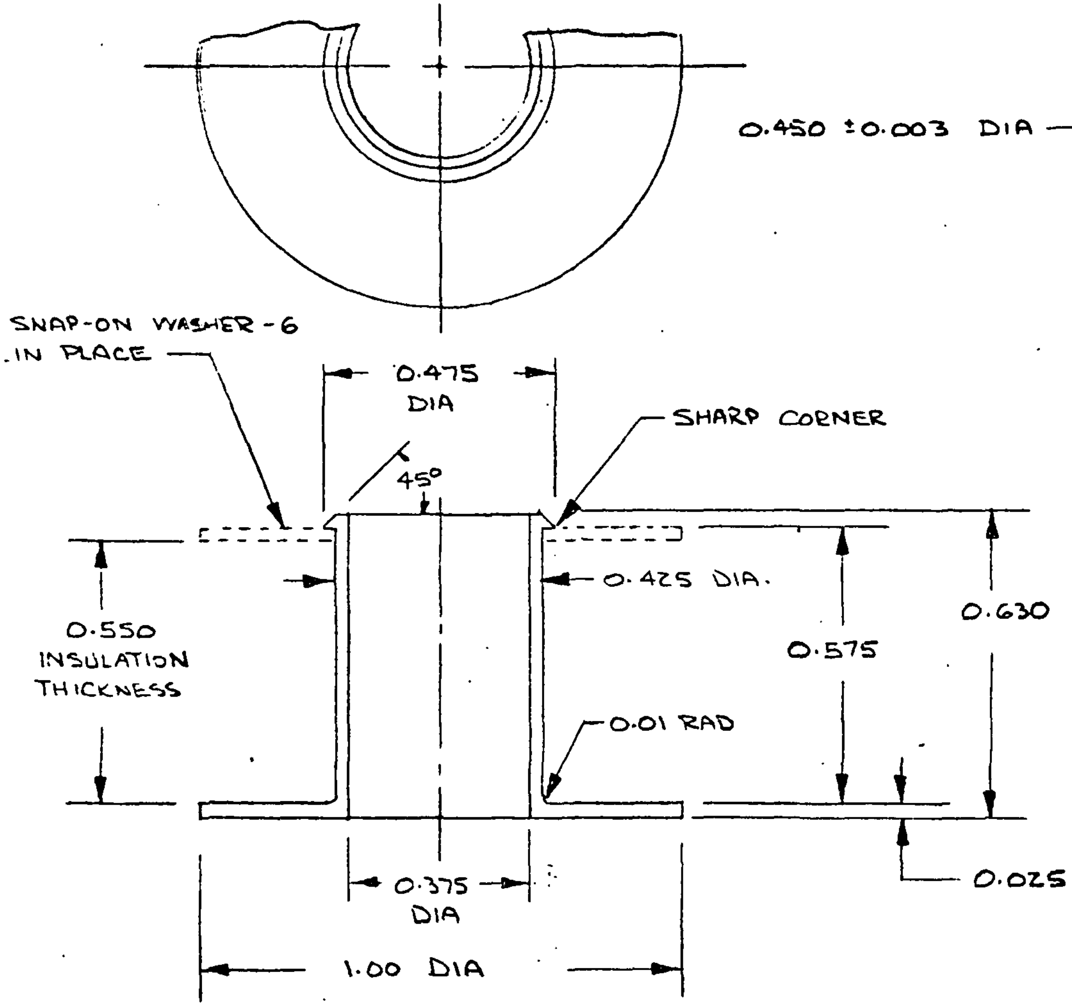
FIGURE A-13
SK 2-5085-147 — MLI FASTENERS



-3
BUTTON - PIN STUD
MAT'L: ZYTEL 103 HSI-L NYLON RESIN
TOLERANCE ON X.XXX IS ± 0.002
(SCALE 4/1)

-4
BUTTON
MAT'L: ZYTEL 103 HSI-L NYLON RESIN
(SCALE 4/1)

FIGURE A-14
SKZ-5085-147—MLI FASTENERS



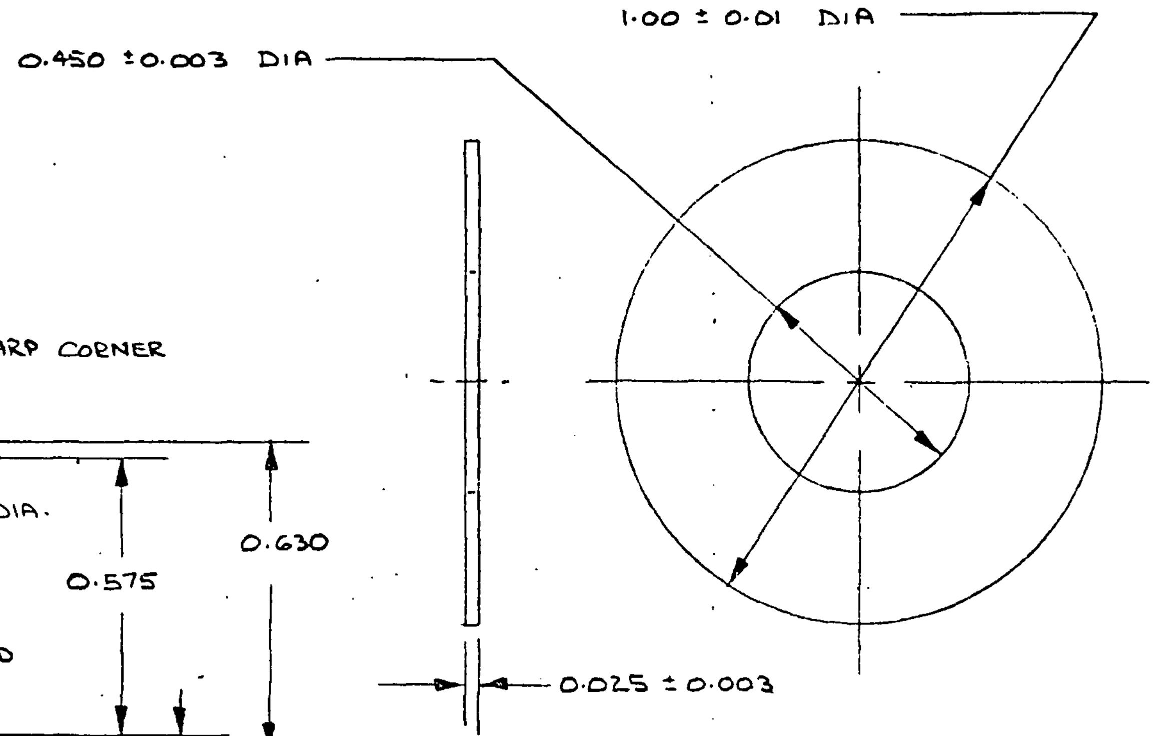
-5

POSITIONING GROMMET

MAT'L: ZYTEL 103 HSI-L NYLON RESIN

TOLERANCE ON X.XX IS ±0.01
ON X.XXX IS ±0.003

(SCALE 4/1)



-6

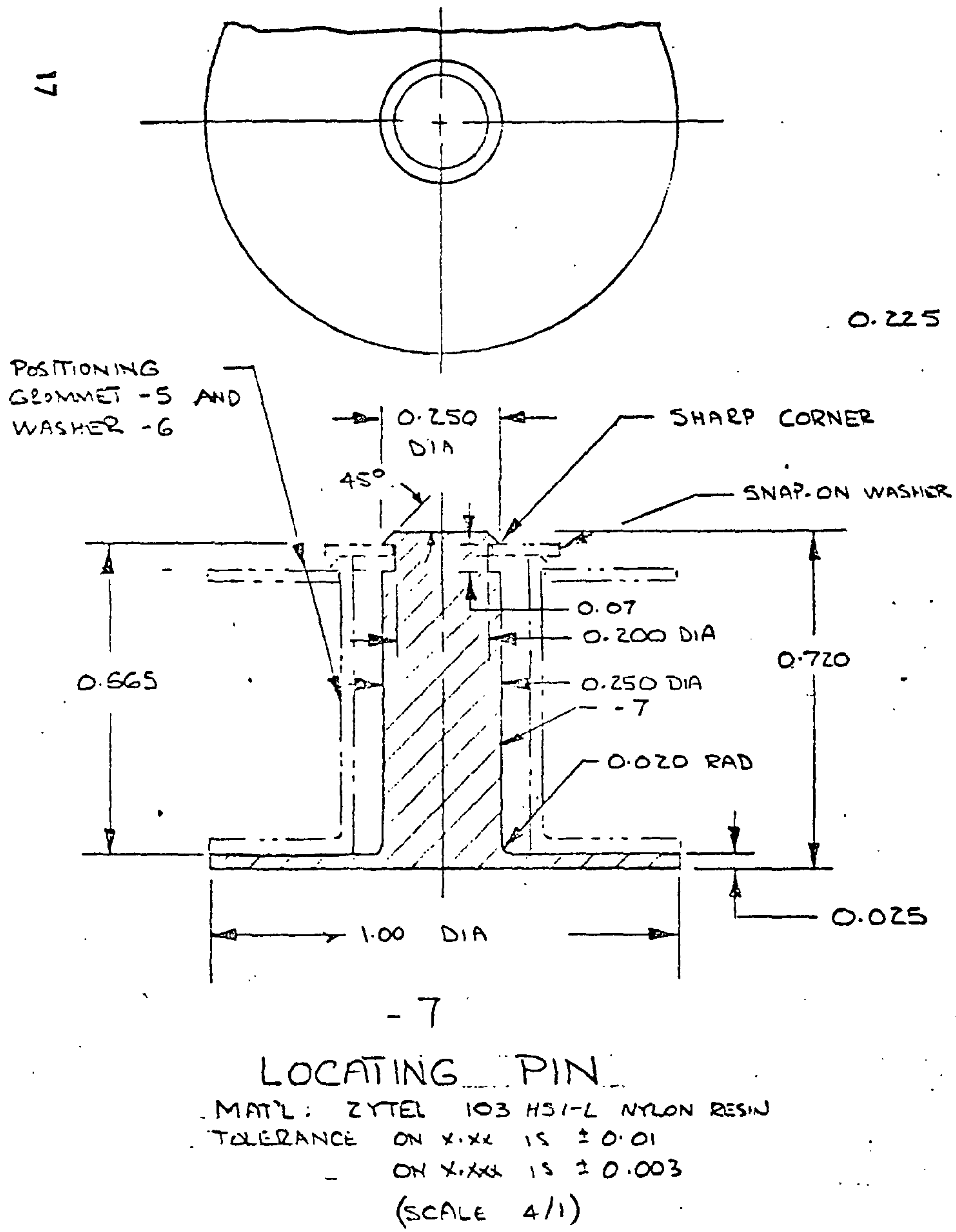
SNAP-ON WASHER

MAT'L: ZYTEL 103 HSI-L NYLON RESIN

(SCALE 4/1)

FIGURE A-15

SK2-5085-147—MLI FASTENERS



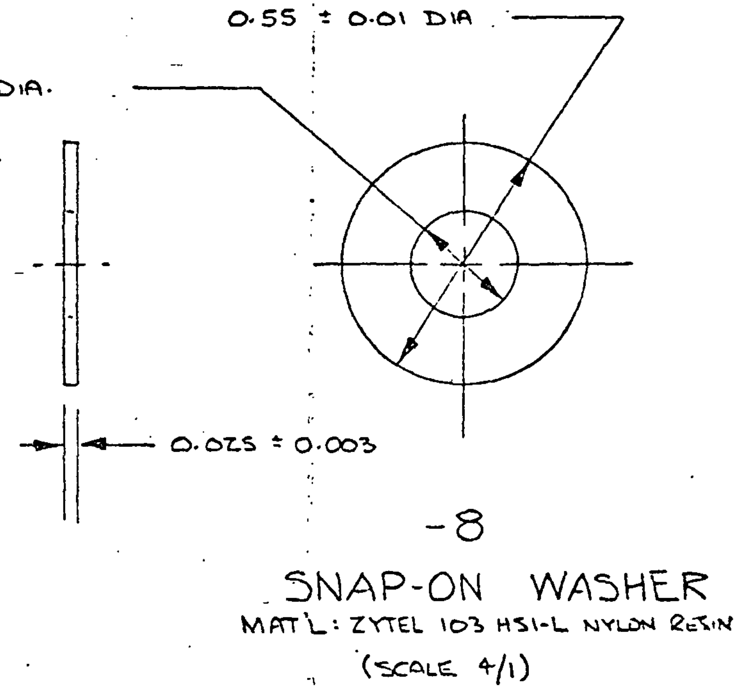


FIGURE A-16
SK2-5085-147—MLI FASTENERS

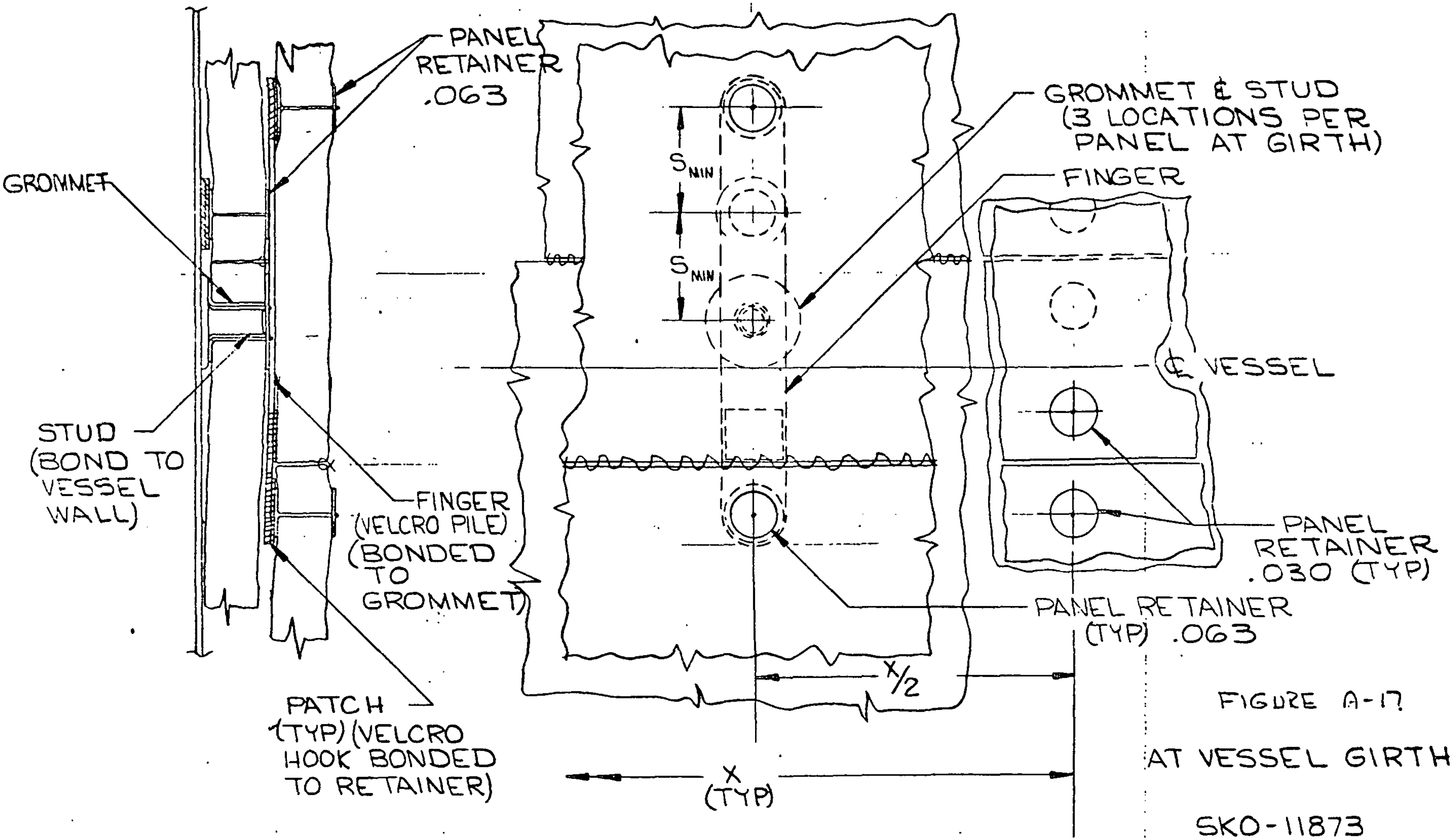


FIGURE A-17

AT VESSEL GIRTH

SKO-11873

INSULATION PANEL RETENTION SYSTEM

SHT 1 OF 5

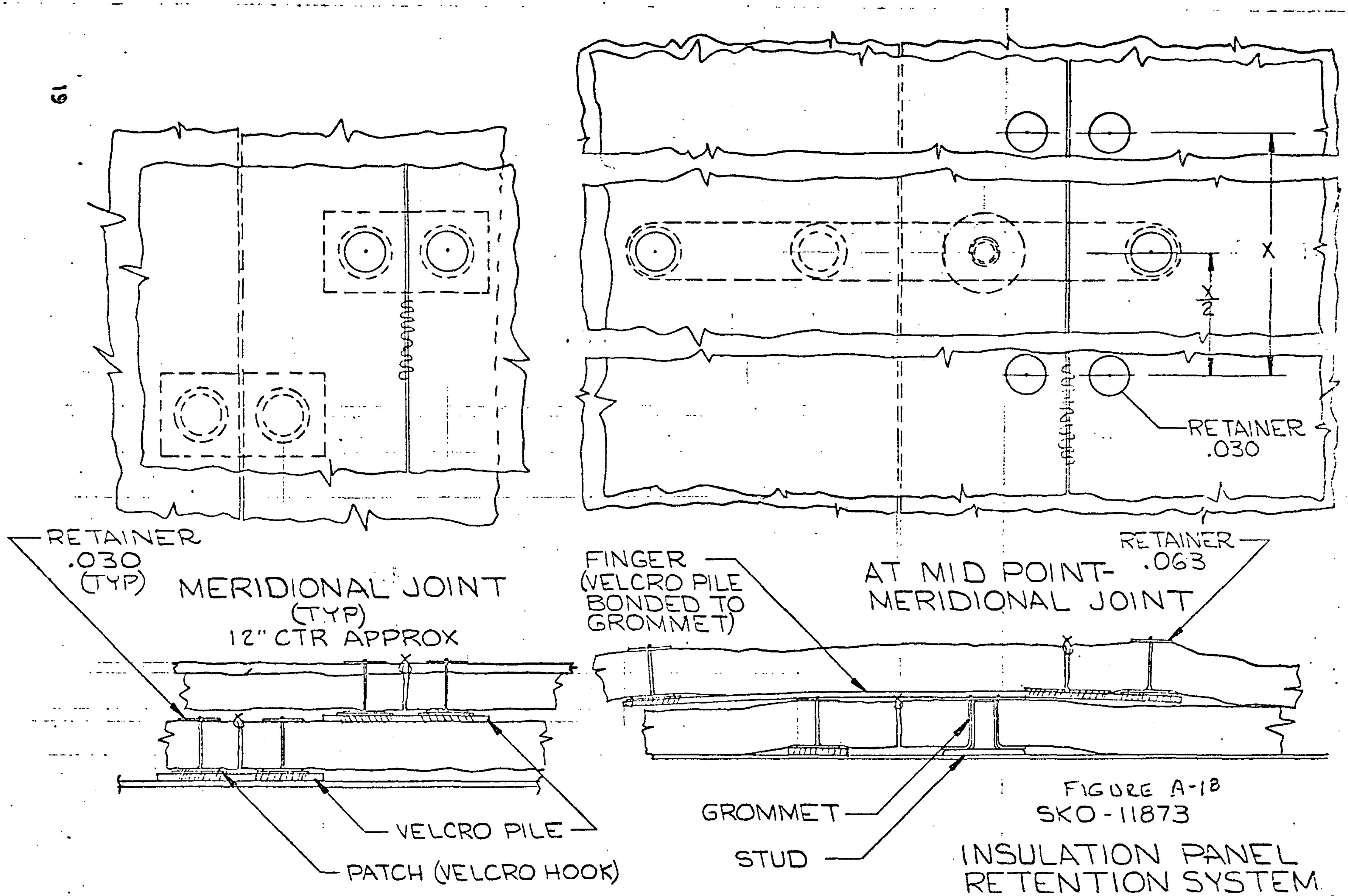
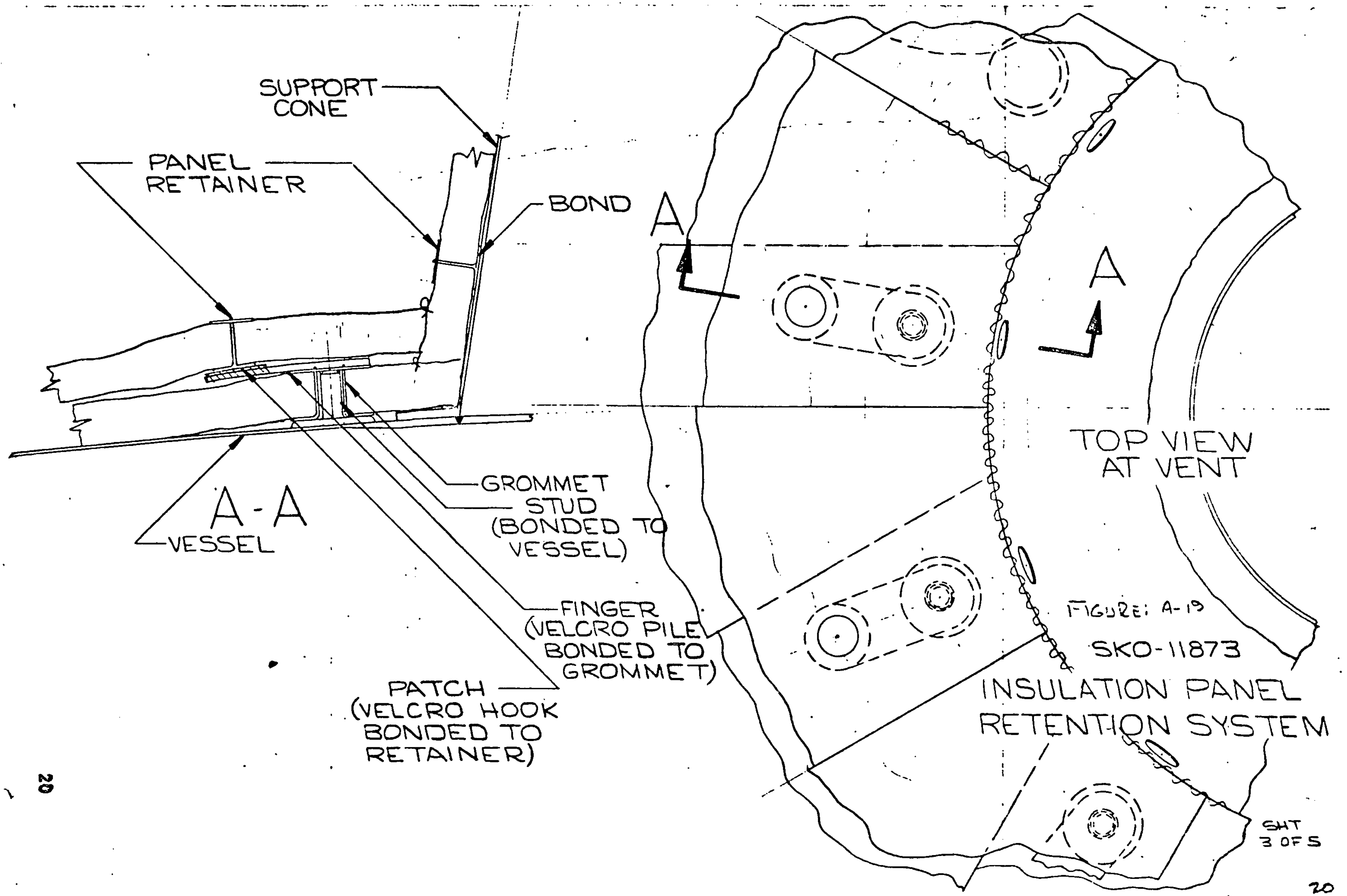


FIGURE A-18
SKO-11873

INSULATION PANEL RETENTION SYSTEM

SHT 2 OF 5


SUPPORT CONE
PANEL RETAINER
BOND
A
A
A-A
VESSEL
GROMMET
STUD (BONDED TO VESSEL)
FINGER (VELCRO PILE BONDED TO GROMMET)
PATCH (VELCRO HOOK BONDED TO RETAINER)
TOP VIEW AT VENT
FIGURE: A-19
SKO-11873
INSULATION PANEL RETENTION SYSTEM
SHT 3 OF 5

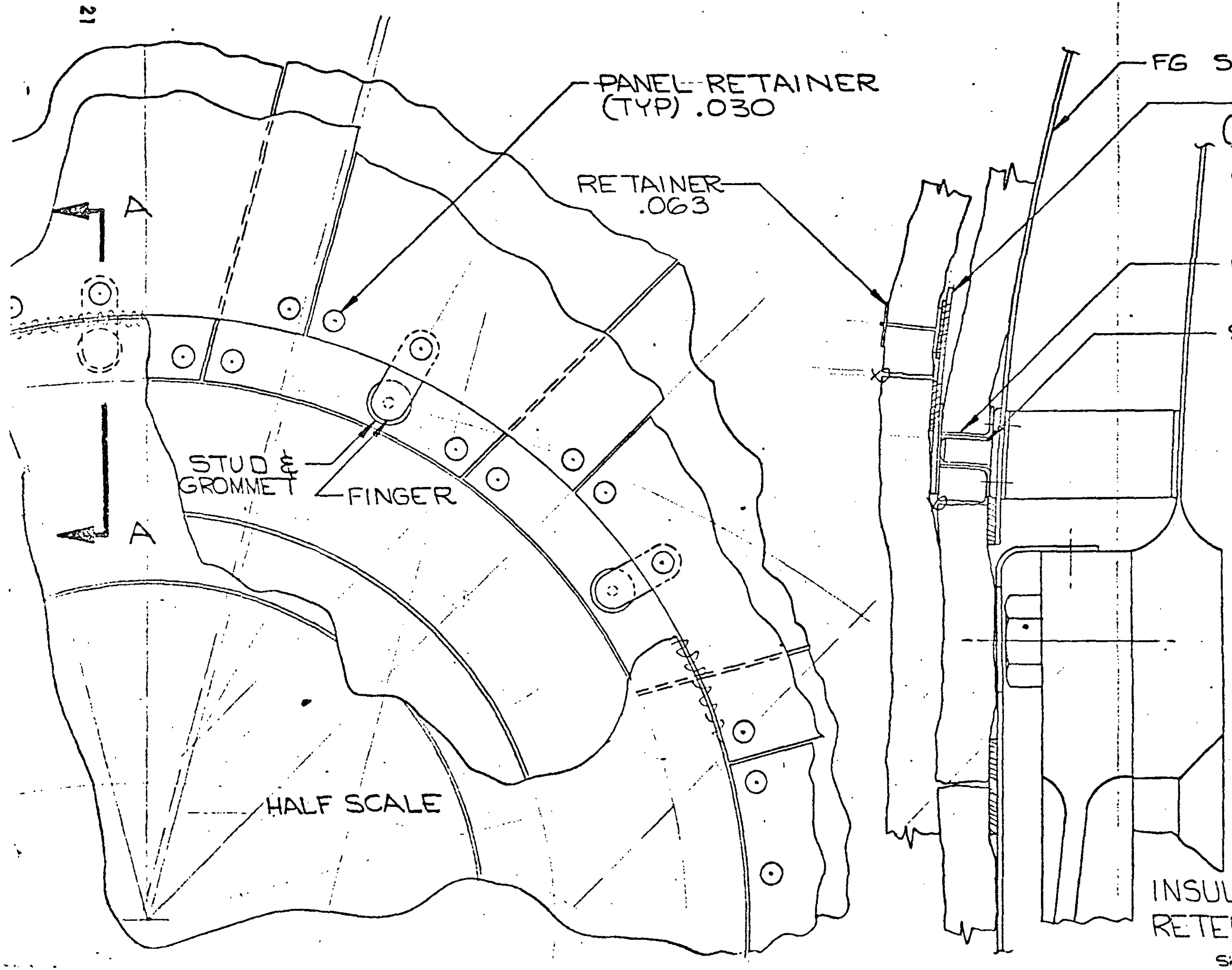
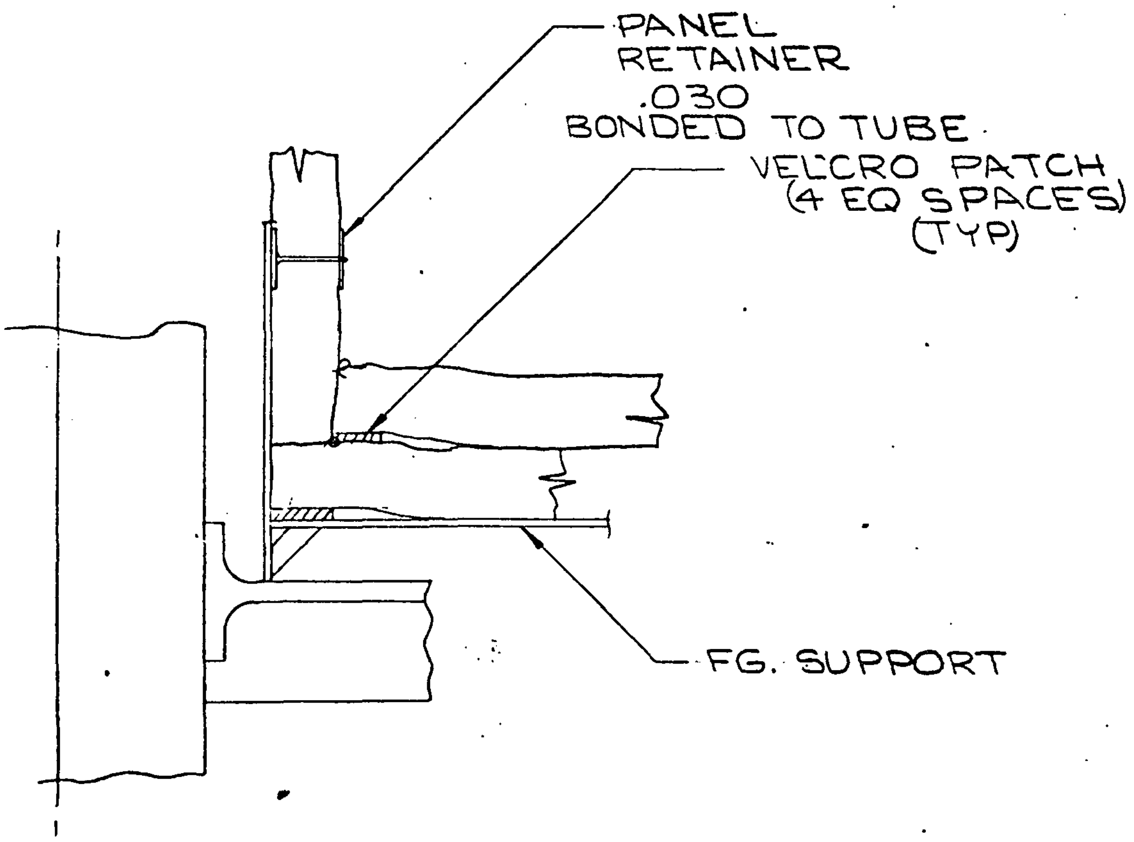


FIGURE: A-20

SKO-11873

INSULATION PANEL RETENTION SYSTEM

SHT 4 OF 5.



VIEW AT MANHOLE
FEED LINE PENATRATION

FIGURE: A-21
SKO-11873

INSULATION PANEL
RETENTION SYSTEM
SHT 5 OF 5

APPENDIX B

MODIFIED THEORETICAL EFFECTIVE GAS CONDUCTIVITY

APPENDIX B

MODIFIED THEORETICAL EFFECTIVE GAS CONDUCTIVITY

In Reference 1 an expression for elemental heat transfer due to free molecule gas conduction was derived for open net MLI systems employing layer densities from 2.0 to 4.0 layers per mm (51 to 102 layers per inch). That expression is

$$q_x = \alpha k_g \left(\frac{h}{h + \ell}\right) \frac{dT^*}{dx} \qquad (8)^*$$

where

q_x = heat flux in the x direction
α = accommodation coefficient
k_g = true gas conductivity
h = thickness of one shield plus one space (layer interval)
ℓ = mean free path
T = temperature
x = MLI thickness dimension

After substitution of curve-fit formulas expressing the gas property parameters of Equation (8) in terms pressure, temperature and molecular weight, the equation becomes

$$q_x = \frac{a_o\ T^n\ a_1\ T^m h}{\left[\dfrac{8.6\ a_2\ T^o T^{.5}}{pM^{.5}}\right]} = \frac{dT}{dx} \qquad (10)$$

*Equation numbers, units and nomenclature (except where conflicting with symbols used elsewhere in this report) are those of Reference 1.

for which the gas-dependent constants are:

Gas	a_o	n	a_1	m	a_2	o	M
H_2	2.66	-.42	$.971 \times 10^{-5}$	.92	1.5×10^{-6}	.7	2.016
He	1.17	-.333	2.35×10^{-5}	.74	5.0×10^{-6}	.65	4.003
N_2	1.0	0	1.38×10^{-6}	.92	1.2×10^{-6}	.9	28.013

The values for a_2 and o (gas viscosity constants) were not listed directly in Reference 2 but were derived here from the curves of the reference.

With $h \ll \ell$ (free molecule regime), Equation (10) may be simplified to

$$q_x = \left[C(T)^S \; ph\right] \frac{dT}{dx} \tag{12}$$

or

$$q_x = \frac{C \; p \; T^S}{\overline{N}} \frac{dT}{dx}$$

where

$C = f(a_o, a_1, a_2, M)$
$S = f(n, m, o)$
$\overline{N}$ = number of layers per unit of thickness
$\overline{N} = 1/h$

In Reference 1, Equation (12) was integrated under the assumption that T varied with x but p was independent of x. The result was

$$q_g = \frac{C_p}{N_o(S+1)} \left[T_H^{S+1} - T_C^{S+1}\right] \tag{13}$$

or

$$q_g = \frac{C_p}{x\overline{N}\,(S+1)} \left[T_H^{S+1} - T_C^{S+1}\right]$$

For the free molecule regime, however, Knudsen's principle (Reference 3) states that

$$\frac{\partial}{\partial x} \left(\frac{p}{T^{.5}} \right) = 0$$

If it can be assumed that

$$\frac{\partial}{\partial x} (pT^{S}) \approx \frac{\partial}{\partial x} (pT^{-.5}) = 0$$

then from Equation (12)

$$q_g = \frac{C}{N\ x} pT^{S}(T_H - T_c)$$

Because of the independence of (pT^S) of x, the non-subscripted p and T may be evaluated at any consistent location within the MLI, usually most conveniently at the hot surface. The effective gas conductivity, which follows directly from the preceding expression, has exactly the same form as the previously used semi-empirical formula,

$$k_g = \frac{C}{N} pT^{S} \tag{A}$$

The gas-dependent constants of Equation (10) were used to evaluate C and S for use in the above formula. The values, along with the corresponding values for the previous, semi-empirical effective conductivity expression are shown below.

Gas	C, $\frac{\text{watt-m}}{\text{mm-N-K}^{S+1}}$	C, $\left(\frac{\text{Btu}}{\text{ft}^2\text{-hr-Torr-R}^{S+1}}\right)$	S
H_2	.244	(7610)	-.70
He	.111	(3460)	-.74
N_2	.0575	(1790)	-.48
N_2, He (Previous Semi-Emp. Formula)	.0266	(828)	-.5

The newly derived theoretical values of S fail to satisfy exactly the assumption that

$$\frac{\partial}{\partial x}(pT^S) \approx \frac{\partial}{\partial x}(pT^{.5})$$

but are close enough to the ideal value of 0.5 to offer hope as to the validity of the theoretical formula for k_g. In order to test this validity predictions were made for comparison with effective gas conductivity test data of reference 4. Results of this comparison, shown in Figure A-1, support the validity of the theoretical expression, Equation (A), at least for N_2. On the basis of this correlation, the validity for H_2 was assumed and Equation (A) was adopted for subsequent thermal analyses in the current program.

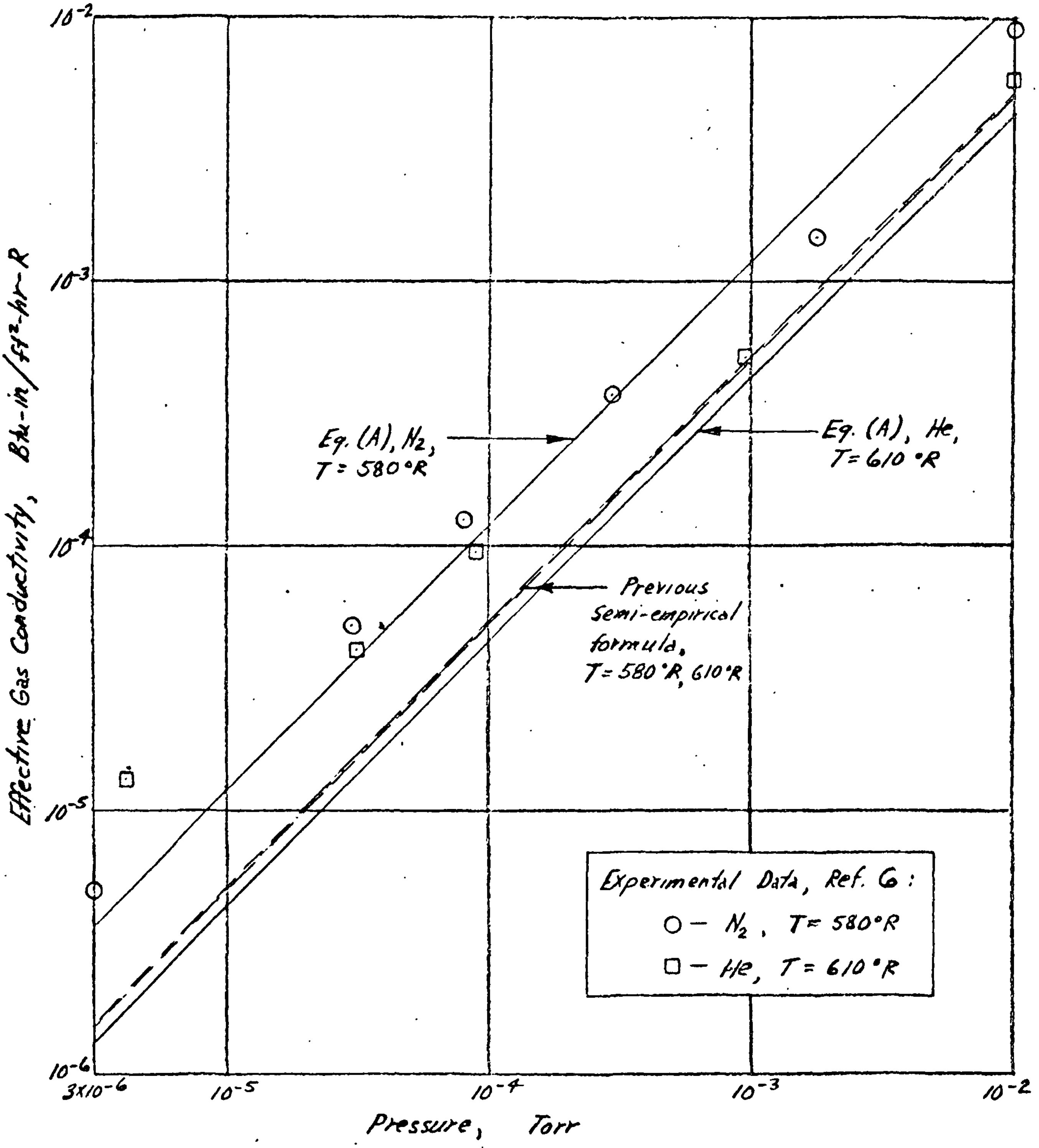


FIGURE B-1

EFFECTIVE GAS CONDUCTIVITY THEORY-EXPERIMENT COMPARISONS

REFERENCES

1. Keller, C. W., "Thermal Performance of Multilayer Insulation," Sixth Quarterly Activity Report, 1 October - 31 December 1972, Contract NAS3-14377, LMSC/D337102, Lockheed Missiles and Space Company.

2. Vance, R. W., and Duke, W. M., Applied Cryogenic Engineering, John Wiley and Sons, N.Y., 1962.

3. Kennard, E. H., "Kinetic Theory of Gases," McGraw Hill, New York, 1938.

4. Ottestad, J. T., "Cryogenic Tank Insulation Properties Measurement," D2-113369-1, The Boeing Company, September 1971.

APPENDIX C

ANALYTICAL THERMAL MODELS

APPENDIX C
ANALYTICAL THERMAL MODELS

The analytical models used in the detailed thermal analysis are illustrated in Figures C-1 through C-7. Symbols employed in the illustrations are explained in Table C-1. The figures show the network of thermal conductors for each case treated, in order to provide an indication of the degree of detail to which the conduction heat paths were considered. Radiation heat paths, which in the analyses connected each pair of terminal nodes between which radiation interchange was significant, have been omitted from the figures for clarity. Although the analytical models, as currently defined, represent details of the full scale design, most of them can be easily adapted to analysis of the subscale design. The following paragraphs describe features of the individual models.

1. Idealized MLI Blankets

The basic heat flow across the idealized MLI, i.e., blankets having no discontinuities or penetrations, was computed with the aid of the one-dimensional model illustrated in Figure C-1. The total heat path included conduction across the vacuum jacket skins, coupled radiation and conduction across the vacuum jacket core, radiation across the vacuum annulus, effective conduction across the MLI, and conduction across the pressure vessel wall. For the steady state analysis, representing the 30-day LH_2 storage condition, constant boundary temperatures at T1 and T10 of 311.0K (560R) and 20.5K (37R), respectively, were assumed. For the transient analysis, representing response to an assumed orbiter reentry with an empty tank, the temperature at T1 was defined to follow a prescribed history while all other nodes were free to respond. The interface between the two MLI blankets was effectively ignored with the assumption of continuous properties through the entire MLI thickness. The MLI thickness was varied parametrically in the basic heat flow analysis in order to develop data required for thermal optimization.

2. Typical Lap Joint

Figure C-2 shows the model used to compute the incremental heat leak per unit length of single-step lap joint in the MLI. The two-dimensional model represented a 65.0 cm (26.6 in) wide section of blanket perpendicular to the joint. It was assumed that this section was wide enough to effectively isolate the influence of the joint on the basic heat flow. The gap at the butt interfaces in the joint, which had an important effect on the magnitude of the joint incremental heat leak, was assumed as .0127 cm (.050 in). As in the basic heat flow analysis, the MLI thickness was varied parametrically.

Unlike the basic heat flow model of Figure C-1, the joint analytical model did not include the vacuum jacket or the vacuum annulus. Instead, the temperatures at the outer surface of the MLI (T1, T8, T15, T22, ..., T85 in Figure C-2 were defined as fixed at the value derived from the corresponding point (T5, Figure C-1) from the basic heat flow analysis. The temperatures along the pressure vessel wall (T7, T14, T21, T28, ..., T91) were fixed at the cold boundary condition of 20.5K (37R).

3. Pin-and-Grommet Fastener

The model used for analyzing the pin-and-grommet (MLI panel installation) type fastener is shown in Figure C-3. This is the design for which alternatives having lower heat leaks are being considered. As in the case of the lap joint, the model includes an area of MLI assumed sufficient to isolate the thermal influence of the fastener. The analytical model is two-dimensional but, by virtue of assumed axial symmetry, represents the fastener and a surrounding circular area of MLI 52.07 cm (20.5 in) in diameter. In a manner similar to the previously described models, the MLI thickness and the affected lengths of pin shaft and grommet wall were varied parametrically. For the purpose of computing radiation interchange in the annular space between the pin and the grommet, the pin was assumed to be positioned concentric with the grommet.

The high temperature boundary condition, at T61, T60, T63, T21, T27, T33, T39, and T45, was set at the computed value for T5 from Figure C-1. The

cold (20.5°K) boundary condition was assumed to exist at T65, T64, T67, T26, T32, T38, T44, and T50.

4. Pin Fasteners

Figure C-4 shows the model used for analyzing the pin-type (MLI panel assembly) fasteners. Because of the alternating positions of the fasteners in the two blankets and the possibility of thermal interactions between pairs of fasteners, it was necessary to employ a three-dimension analytical model. For the fastener pattern assumed, the minimum size recurring cell is the triangular area shown in the figure. The validity of such a recurring cell for an analytical model depends upon infinite repetition of the pattern. Its use here assumes no interactions between the pin-type fasteners and the pin-and-grommet fasteners, MLI lap joints, or other penetrations. For analysis of the pin-type fasteners, both the MLI thickness (Dimension "B" in the figure) and the pin spacing (dimension "A") were varied parametrically. Boundary temperatures were prescribed on the MLI surfaces and the surfaces of exposed pin heads in a manner similar to that used for the pin-and-grommet and lap joint analyses.

5. Structural Support Strap

Figure C-5 illustrates the model used to analyze the incremental heat flow due to a typical support strap penetration. This penetration was actually treated in two parts: the strap itself, as a direct conductor of heat to the pressure vessel; and the MLI in the vicinity of the strap attachment on the pressure vessel wall. Both components of the model are shown in the figure.

The actual MLI blanket design at the strap penetration includes a number of cuts, seams, and joints. The modelling of these details, especially in view of the difficulties in estimating the dimensions of gaps and spaces at joints and the effects of compression of the MLI, appeared to be a formidable task and one of questionable value. It was observed that the design provided total MLI thicknesses at least equal to the basic thickness everywhere around the strap except in the vicinity of the attachment boss.

It was therefore assumed that the total heat leak due to the strap penetration could be estimated as the sum of the heat flow through the strap and the increased heat flow through the MLI due to the reduced thickness over the strap attachment bolt.

The strap was considered a one-dimensional conductor between the point where it emerged from the insulation cover to the thickened lug on its pressure vessel end. Those two points, designated at T51 and T20 on Figure C-5, were fixed at 311.0°K (560°R) and 20.5°K (37°R), respectively.

The MLI analysis employed a two-dimensional model of an axially symmetric area 52.07 cm (20.5 in) in diameter, centered on the strap attachment bolt. No interaction between the strap and the MLI was assumed. As in previous cases, the MLI thickness was varied parametrically.

Warm side boundary temperatures, at T1, T8, T15, T21, ..., T45 were again set at the value for MLI outer surface from the basic heat flow analysis. The cold side boundary temperature, at T20, T26, T32, T38, T44, and T50, were set at 20.5°K (37°R).

6. <u>Manhole Access and Feed Valve Assembly</u>

The model for analysis of the manhole and feed valve penetration is shown in Figure C-6. The heat flow through this region was expected to be a complex combination of conduction and radiation with the thermal influence extending well beyond the periphery of the assembly.

With the exception of the two small vent and valve actuator tubes, the network shown in the figure was treated as axisymmetric. Heat flow through the two small tubes was computed on an independent, one-dimensional basis and added to the heat flow resulting from the axisymmetric model analysis. Radiation interchange between the small tubes and other surfaces was thus ignored, but all other possible radiant exchanges permitted by the nodal network, including radiation through the main feed line interior, were

considered. The conductor values for the two small coiled tubes were based on their true length, although the figure shows shorter lengths for clarity.

The model for manhole and feed valve penetration analysis included pressure vessel, MLI blanket, vacuum annulus, and vacuum jacket area out to a radius of 107 cm (42 in) from the feed line. The thickness of the main MLI blanket was taken as 2.79 cm (1.10 in) and the feed line MLI as 1.27 cm (0.50 in) rather than being varied as in some of the other component analyses. It was assumed that within the range of MLI thicknesses of interest for optimization purposes, the incremental heat leak associated with the manhole and feed valve penetration would be little affected by variations in thickness. The joints in the main MLI providing access to the manhole cover bolts were not included as part of this model but were included as part of the total length of joint in the computation of total joint heat leak.

Boundary temperatures for the model of Figure C-6 were 311.0°K (560°R) at T1, the outer, warm surface, and 20.5°K (37°R) at T2, at the cold boundary.

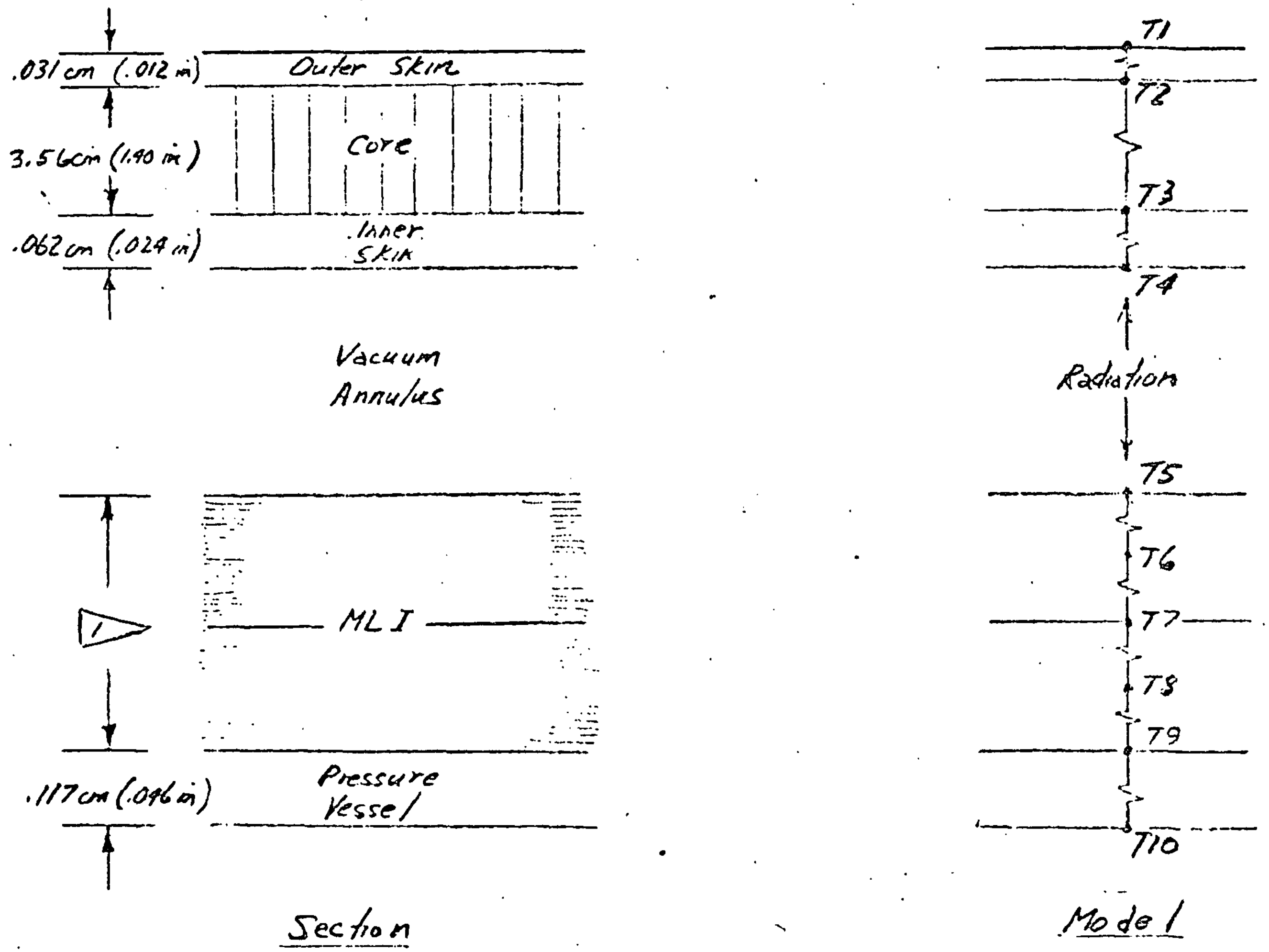
7. Vent Valve Assembly

Figure C-7 shows the analytical model for the vent valve assembly penetration. Although the model was developed as illustrated, the analysis of this penetration, as described in the discussion of predicted heat flow results, did not incorporate all details of the model. Specifically, radiation within the valve enclosure and its vacuum jacket housing, and lateral heat flow in the pressure vessel MLI and the entire vacuum jacket were ignored. The analysis did include conduction through the main vent line, valve enclosure, insulation support collar, valve enclosure MLI (laterally only), and the valve enclosure vent and valve actuator tubes, as well as radiation through the main vent line interior. Boundary temperatures for the analysis were 20.5°K (37°R) at T70 and 311.0°K (560°R) at T1 and T69.

TABLE C-1

SYMBOLS FOR ANALYTICAL THERMAL MODEL DIAGRAMS

	—	Terminal Node: Terminus for thermal conductors, point at which temperatures are evaluated, point at which surface area (for radiation interchange) and thermal capacitance (for transient thermal diffusion) are assumed concentrated.
	—	Thermal Conductor: Connects two terminal nodes, incorporating properties of material conductivity, conduction path length and conduction path effective cross section area.
	—	Zero Resistance Conductor: Connects terminal nodes whose temperatures are assumed identical.



1 MLI thickness varied parametrically

(NO TO SCALE)

FIGURE C-1

ANALYTICAL THERMAL MODEL — AREAS REMOTE FROM PENETRATIONS OR DISCONTINUITIES

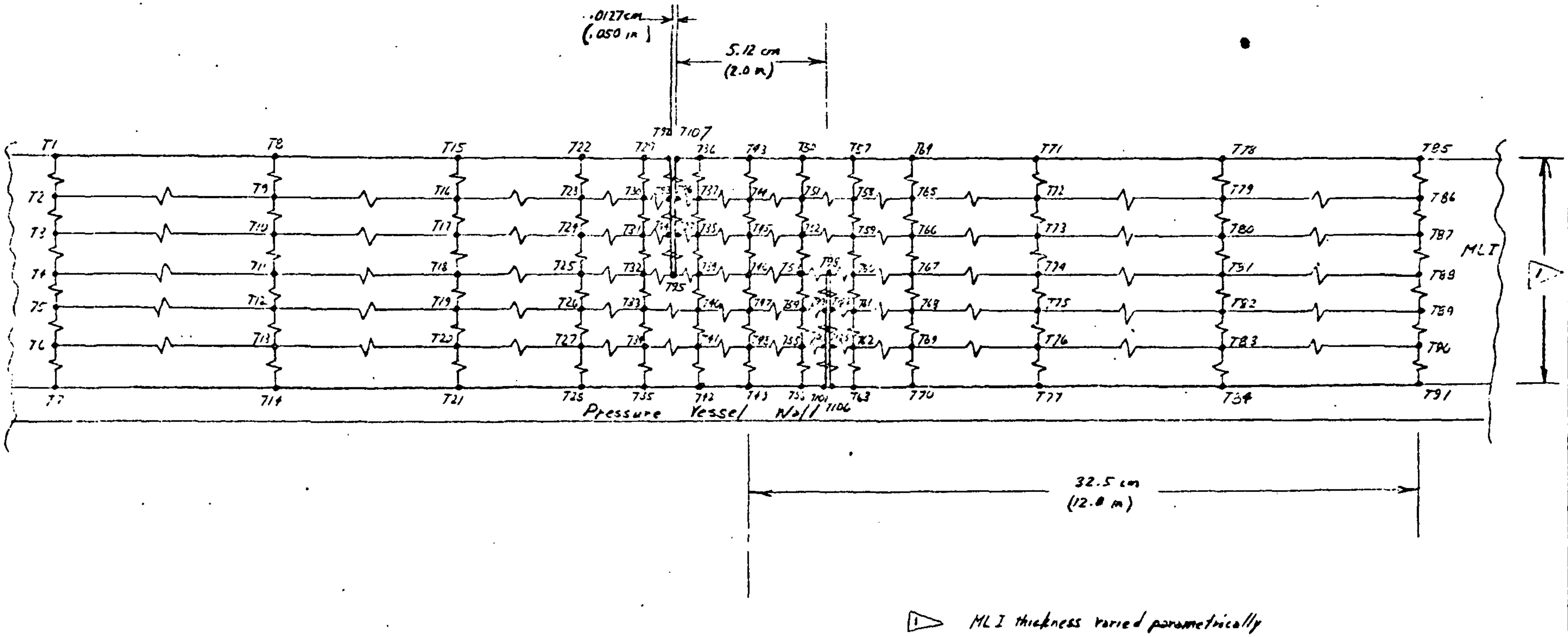


FIGURE C-2

ANALYTICAL THERMAL MODEL - TYPICAL SECTION THROUGH SINGLE-STEP LAP JOINT

(NOT TO SCALE)

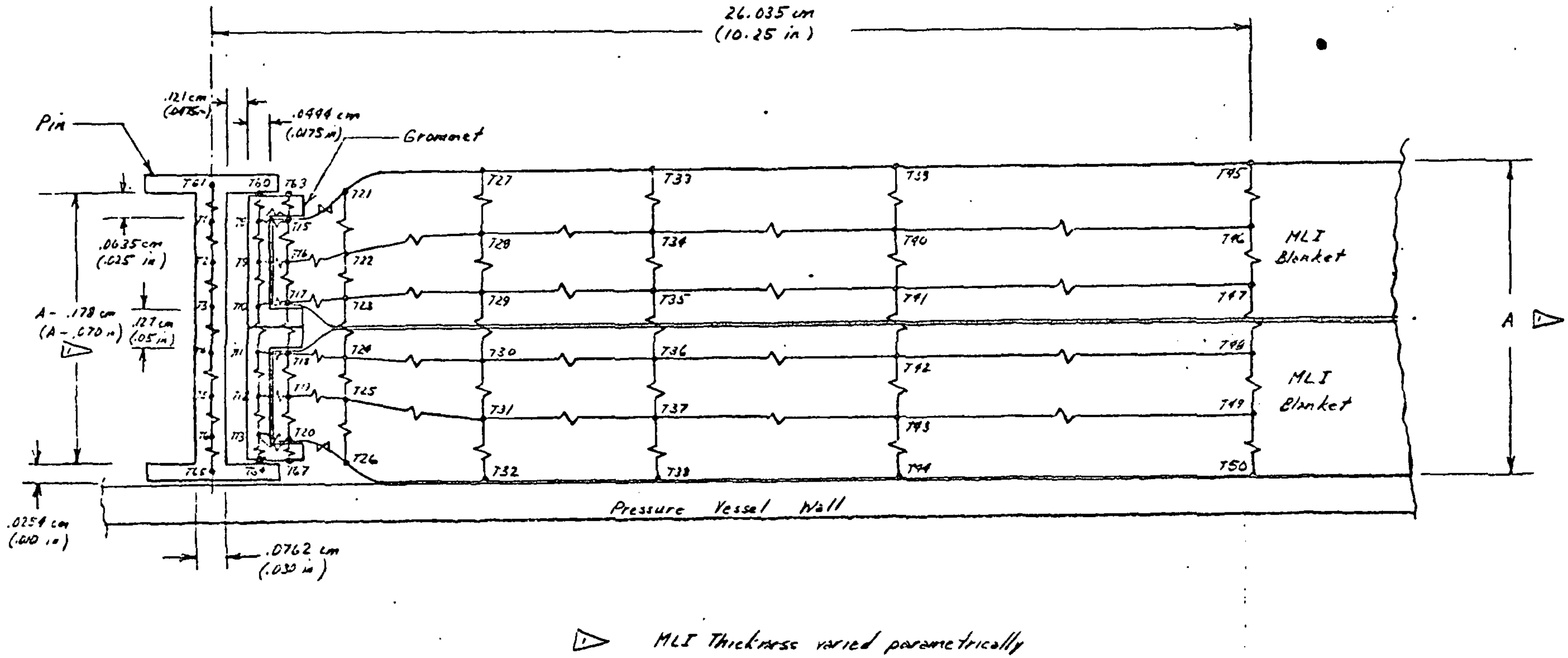


FIGURE C-3

ANALYTICAL THERMAL MODEL - TYPICAL NYLON PIN-AND-GROMMET FASTENER & SURROUNDING MLI
(NOT TO SCALE)

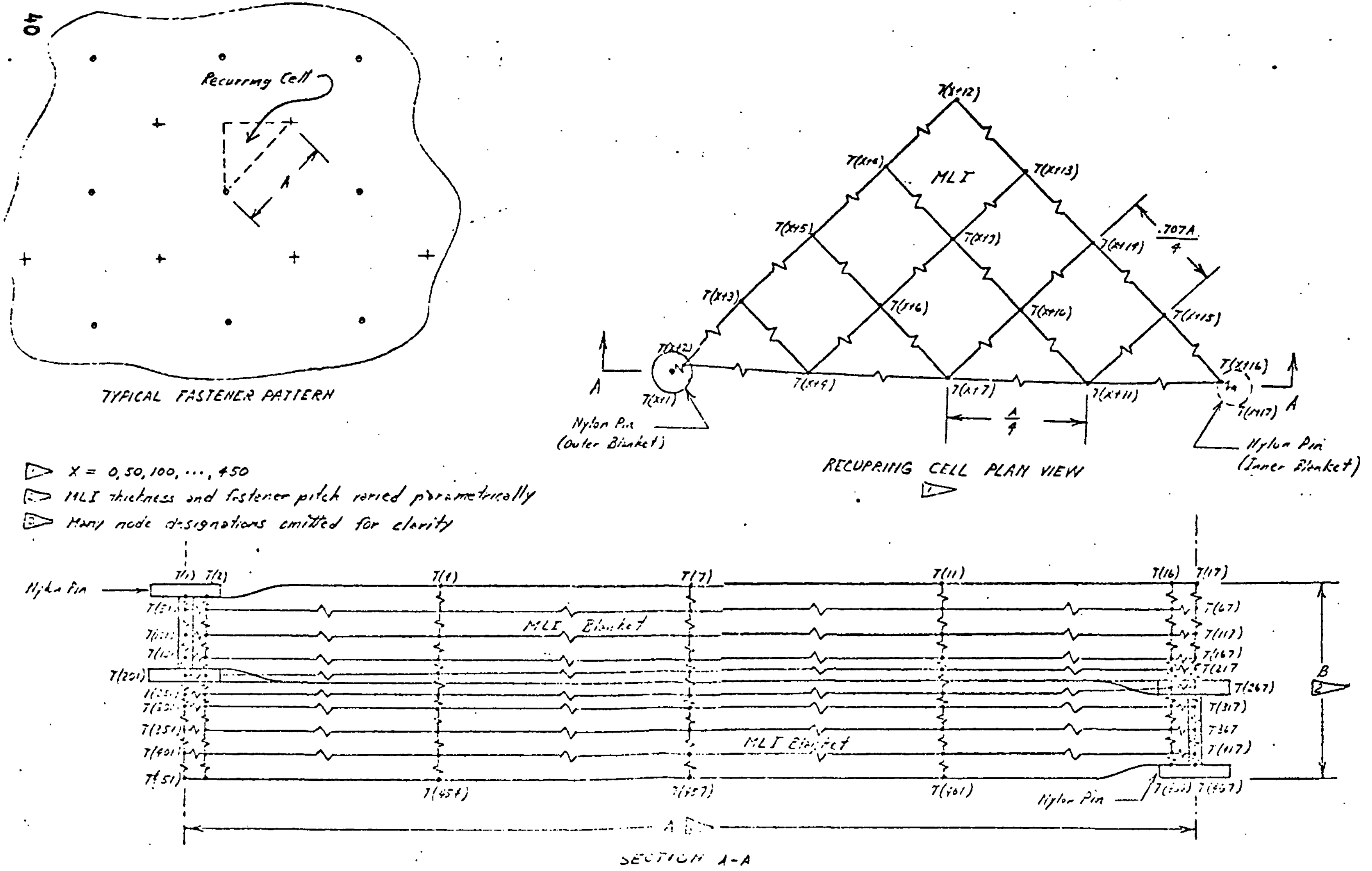


FIGURE C-4
ANALYTICAL THERMAL MODEL- PIN-TYPE FASTENERS & ASSOCIATED MLI (Not to Scale)

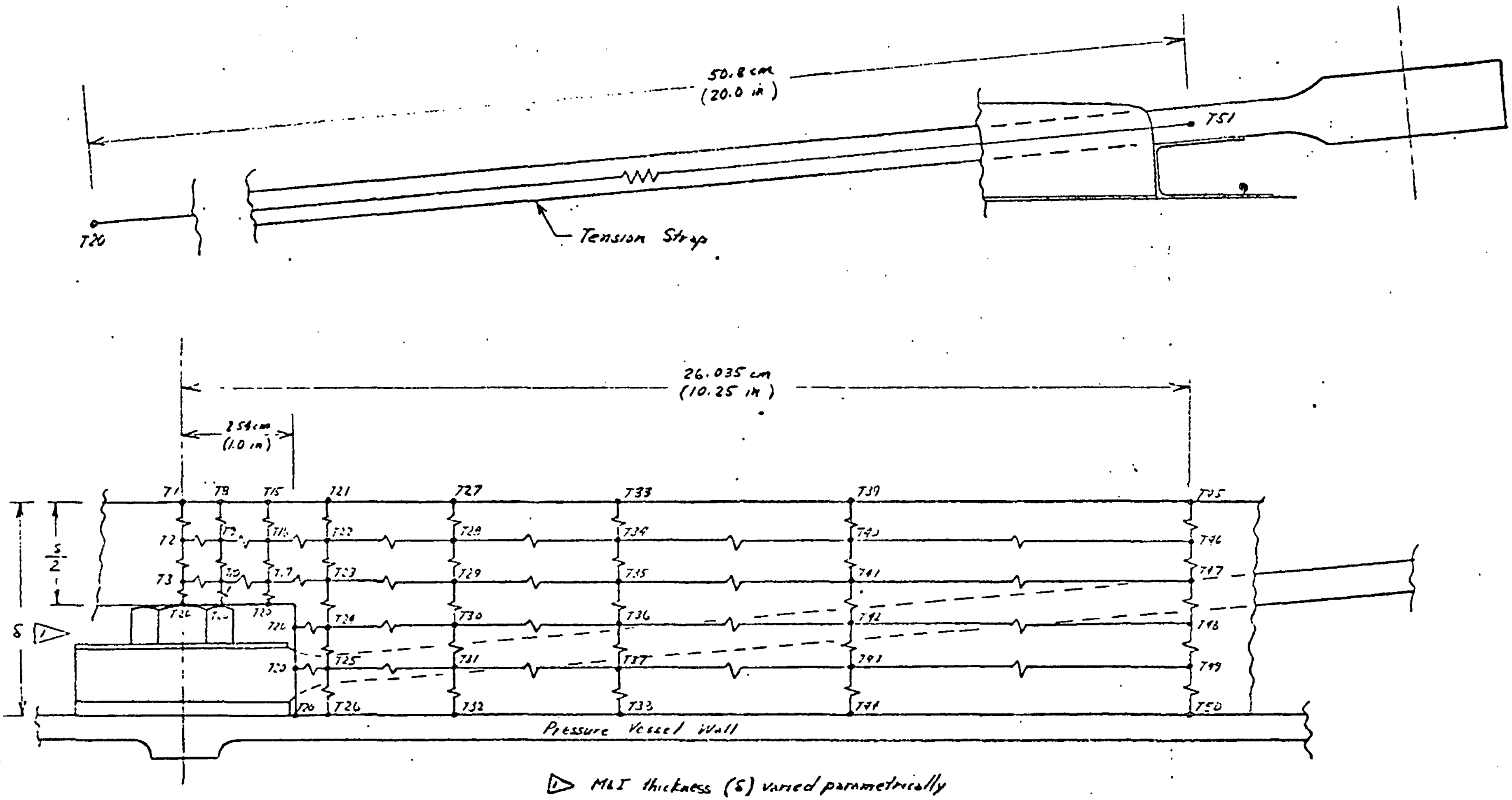


FIGURE C-5.

ANALYTICAL THERMAL MODEL – TYPICAL SUPPORT STRAP AND MLI SURROUNDING ATTACHMENT BOLT (NOT TO SCALE)

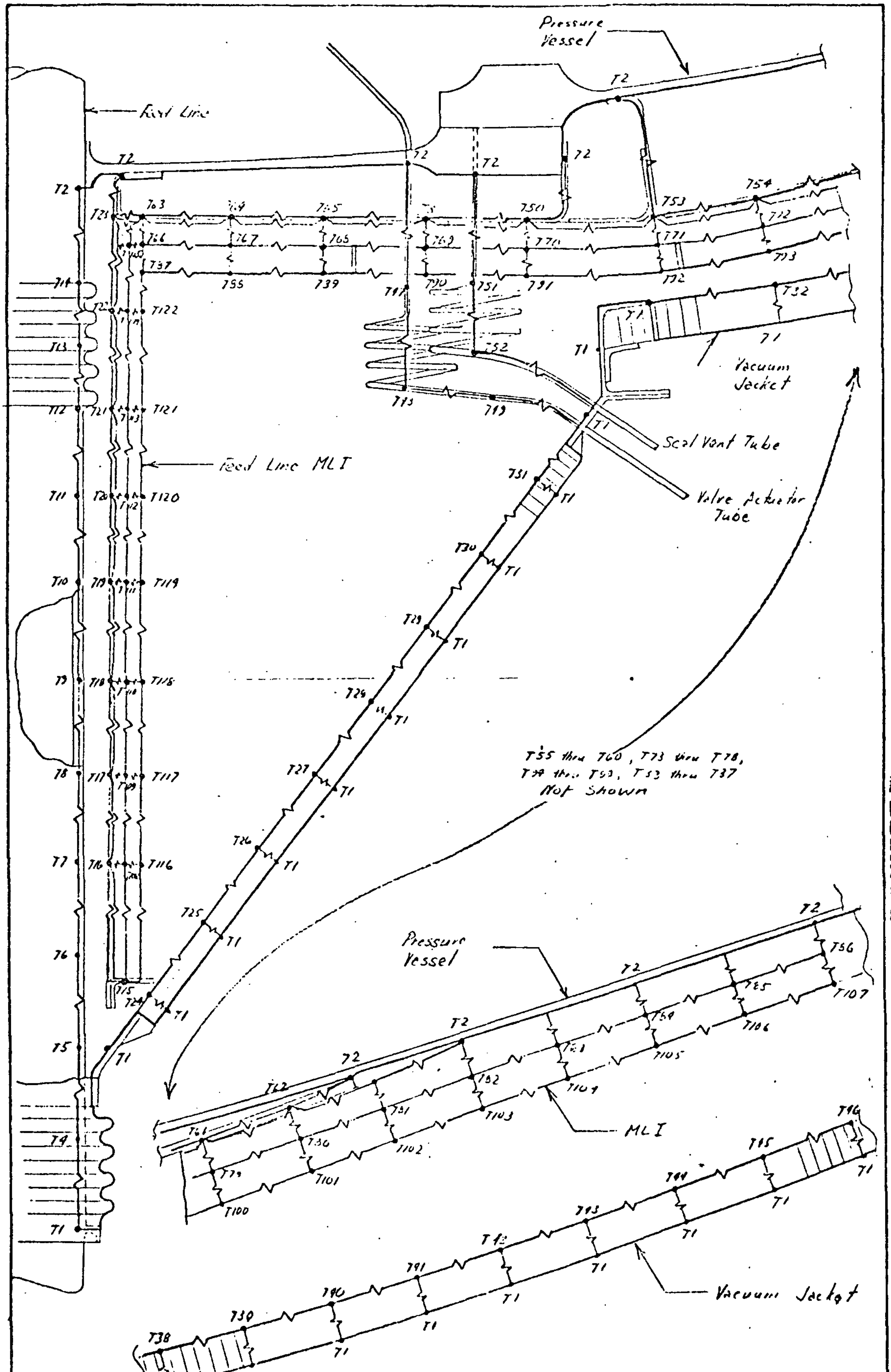


FIGURE C-6
ANALYTICAL THERMAL MODEL -
MANHOLE ACCESS & FEED VALVE ASSEMBLY PENETRATION
(NOT TO SCALE)

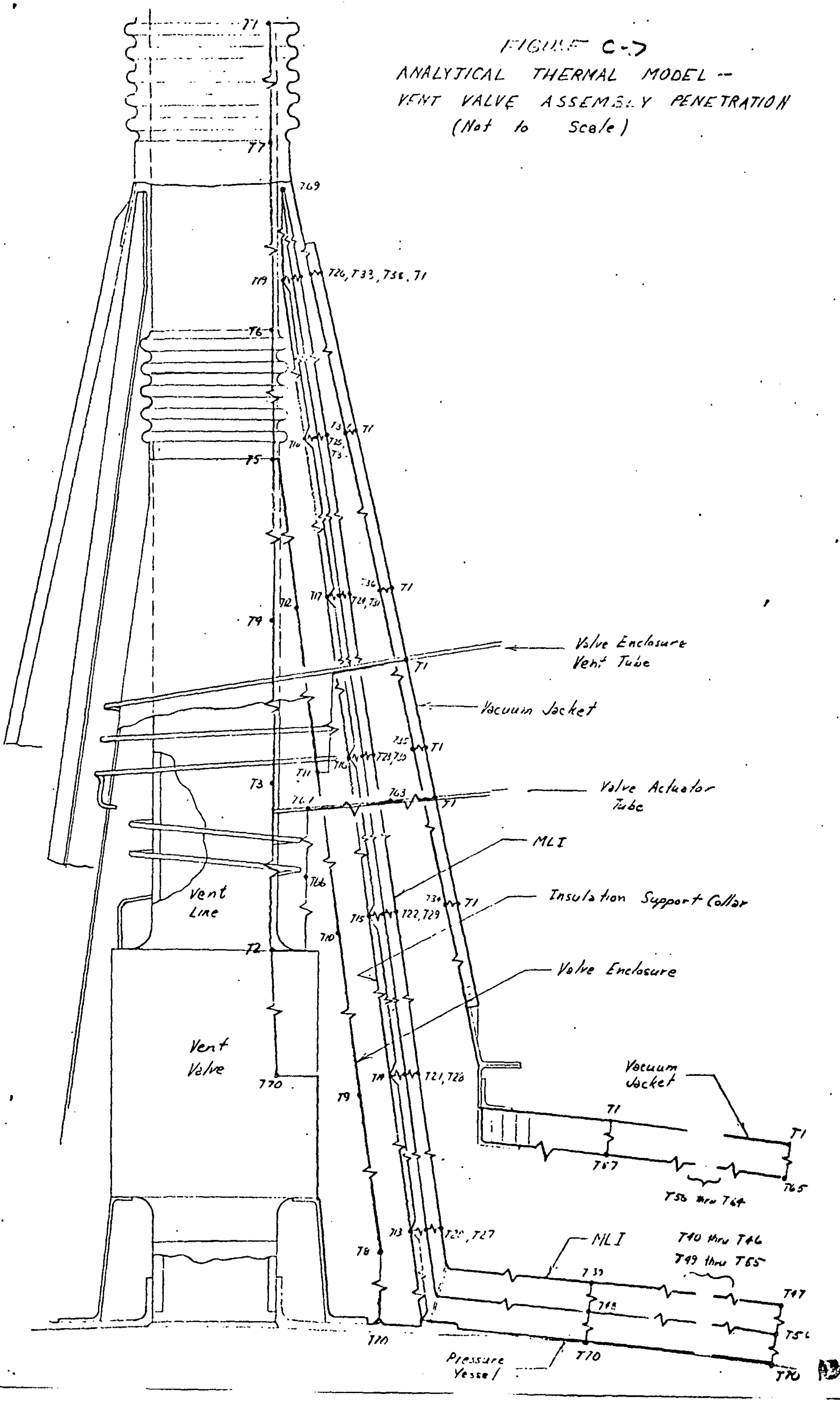
THE BOEING COMPANY

SHEET 42

NUMBER
REV LTR

12

FIGURE C-7
ANALYTICAL THERMAL MODEL --
VENT VALVE ASSEMBLY PENETRATION
(Not to Scale)



APPENDIX D

HALF SCALE LH_2 TEST MODEL DRAWINGS

ASSEMBLY AND QUALIFICATION PROCEDURES

(C) 1 APPLY KEL F #90 (BM) GREASE BETWEEN THE FAYING SURFACES OF THE -6 ATTACHMENT FITTING ASSEMBLIES AND THE EMITR 5183 SUPPORT FIXTURE PILLOW BLOCKS. CLAMP -6 ASSEMBLIES IN PLACE

(A)(D) 2. CENTER THE LH_2 PRESSURE VESSEL ASSEMBLY SK2-5085-139-1 IN THE SUPPORT FIXTURE AND SECURE IT IN POSITION WITH TEMPORARY SUPPORTS. ATTACH THE SUPPORT STRAP ASSEMBLIES SK2-5085-151-1, TURNBUCKLE ASSEMBLIES SK2-5085-163-1 SPRING PINS MS 16562-249, BOLTS BACB30LJ6U11, AND NUTS BACN10JC6CM. ALIGN PRESSURE VESSEL PER [20] AND TORQUE TURNBUCKLES PER [21]

(A) 3 REMOVE TEMPORARY SUPPORTS. SLOWLY ROTATE THE PRESSURE VESSEL IN THE SUPPORT FIXTURE. DURING ROTATION DETERMINE EXTENT OF PRESSURE VESSEL AND SUPPORT STRAP MOVEMENT.

(C) 4 SAW OFF SK2-5085-139-5 TUBE PER SK2-5085-137 SHEET 6. WELD INLET TUBE ASSEMBLY SK2-5085-1634 IN PLACE PER [7] WELD -11 TUBE IN PLACE PER [3]

(C) 5 HELIUM LEAK CHECK PRESSURE VESSEL ASSEMBLY

(C) 6 CLEAN ALL -1 ASSEMBLY SURFACES EXPOSED TO THE VACUUM ANNULUS PER [5] AND ENGINEERING INSTRUCTIONS. WHITE NYLON GLOVES AND COATS (OR EQUIVALENT) SHALL BE WORN BY ALL ASSEMBLY PERSONNEL TO INSURE CLEANLINESS OF ALL SURFACES EXPOSED TO THE VACUUM ANNULUS

(C) 7 INSTALL MLI PANELS PER SK2-5085-141 MLI INSTALLATION

(A)(C) 8 INSTALL VACUUM JACKET HEADS SK2-5085-140-1, INNER JOINT PLATE -3, OUTER JOINT PLATE -4, AND SPLICE PLATE -5.

(C) 9 WELD SEALING SKIN -2 VACUUM JACKET CLOSEOUT ASSEMBIES SK2-5085-154-1 AND SK2-5085-156-1 IN PLACE. HELIUM LEAK CHECK WELDS

NOTES

~~1. SPECIFICATIONS AND STANDARDS FOR THE CONTROL OF MANUFACTURING OPERATIONS (AS APPLICABLE):~~
~~SURFACE ROUGHNESS SYMBOLS PER BACD 2007 — PART MARKING PER BAC 5307~~
~~WELDING AND BRAZING SYMBOLS PER BACD 2023 — BOLT & NUT INSTALLATION PER BAC 5009~~
~~FORM, STRAIGHTEN & FIT METAL PARTS PER BAC 5300 — FINISH CODES PER DOCUMENT D2 5000~~
~~MATERIAL SUBSTITUTIONS & EQUIVALENTS PER BAC 5005 — RIVET INSTALLATION & SYMBOLS PER BAC 5004~~

(E) [23] CRYOLAB DIVISION OF CRYOGENIC ENGINEERING CORP. PART NUMBER

(E) [22] ULTEK DIVISION OF PERKIN-ELMER PART NUMBER

(D) [21] TORQUE [19] TURNBUCKLES ATTACHING SUPPORT STRAPS AS FOLLOWS:
A) AFTER PRESSURE VESSEL ALIGNMENT [20], SET TURNBUCKLES ON LOWER STRAP TO 60 ± 5 IN-LB TORQUE
B) BEFORE SETTING SETTING TURNBUCKLES ON UPPER STRAP FIRST ROTATE PRESSURE VESSEL 180° IN SUPPORT FIXTURE THEN SET TURNBUCKLES TO 60 ± 5 IN-LB TORQUE

(D) [20] ALIGN PRESSURE VESSEL, SK2-5085-139-1 IN SUPPORT FIXTURE EMITR 5183 AS FOLLOWS:
A) TORQUE [19] TURNBUCKLES ATTACHING SUPPORT STRAPS - FINGER TIGHT
B) ALIGN PRESSURE VESSEL BY INCREASING AND DECREASING TORQUE [19] OF TURNBUCKLES.
DO NOT EXCEED 100 IN-LB TORQUE.

(D) [19] DO NOT TWIST SUPPORT STRAPS SK2-5085-151-1

(C) [18] 302 OR 304 CRES WIRE PER QQ-W-423 OR EQUIVALENT

(C) [17] TAPE TO OUTER SURFACE OF OUTER MLI PANELS PER [13]

(C) [16] TAPE TO OUTER SURFACE OF INNER MLI PANELS PER [13]

(C) [15] TAPE TO SK2-5085-139-1 PER [13]

(C) [14] EE-6600 (PERMACEL) REFLECTIVE, POLYESTER, INTERLINED, PRESSURE SENSITIVE TAPE

(C) [13] TAPE THERMOCOUPLES IN PLACE WITH [14], 1.00 × .15 INCHES

(C) [12] WELD PER BAC 5930 CLASS C. INSPECT PER [11]

(C) [11] LEAK RATE SHALL NOT EXCEED 1×10^{-9} STD CC/HELIUM PER SECOND

(C) [10] RADIOGRAPHIC INSPECT PER BAC 5915. PENETRANT INSPECTION SHALL NOT BE USED

(A)(C) [9] COLD SHOCK WELD WITH LN_2 PRIOR TO HELIUM LEAK CHECK

[8] STANDARD PRESSED STEEL PART NUMBER

(C) [7] WELD PER BAC 5935 CLASS A. FILLER WIRE ER 4043 PER QQ-R-566 TYPE 4043 OR MIL-E-16053 TYPE 4043. COLD SHOCK PER [9] INSPECT PER [10] & [11]

[6] BAKE AT 450° K (350°F) IN A VACUUM FOR 2 HOURS. STORE IN SEALED PACKAGE AFTER BAKING TO PRESERVE CLEANLINESS.

[5] ASSEMBLY OF THE TEST MODEL SHALL BE DONE IN A DUST FREE ROOM. ALL ASSEMBLY TOOLS SHALL BE FREE FROM OIL AND PARTICLE CONTAMINATION. METAL SURFACES EXPOSED TO THE VACUUM ANNULUS SHALL BE CLEANED PER BAC 5765. AND THEN PROTECTED FROM OIL AND PARTICLE CONTAMINATION.

[4] HEAT TREAT TO T6 PER BAC 5602

(B)(C) [3] WELD PER BAC 5935 CLASS C. FILLER WIRE ER 4043 PER QQ-R-566 TYPE 4043 OR MIL-E-16053 TYPE 4043. INSPECT PER [11]

[2] 6061 T4 ALUM BAR PER QQ-A-225/8

[1] 6061 T6 ALUM. SHEET PER QQ-A-250/11

REVISIONS

ZONE	LTR	DESCRIPTION	DATE	APPROVED
	A	ADDED SK2-5085-163-1, BACN10JC6CM, & BACB30LJ6U11. DELETED PARTS -11, -12 & -13 [9] [10] [11] [12] ALTERED MAT'L THICKNESS FROM .20 FOR PARTS -7, -8 & -10 ALTERED ASSEMBLY & QUALIFICATION PROCEDURE NOTES 2, 3, & 7.	10/30/73	DLB
	B	REVISED [3]	11/16/73	
	C	ADDED ITEMS -11 THRU -14 & NOTES [7], [9] THRU [18] ALTERED ASSEMBLY NOTES	4/22/74	DLB
	D	ADDED NOTES [19] THRU [21] ALTERED ASSEMBLY NOTE 2	4/29/74	DLB

PARTS LIST

QTY REQD -6	QTY REQD -1	PART OR IDENTIFYING NUMBER	NOMENCLATURE OR DESCRIPTION	ZONE	MATERIAL AND SPECIFICATION
	16	SK2-5085-163-1	TURNBUCKLE ASSEMBLY		
	1	SK2-5085-156-1	VACUUM JACKET CLOSEOUT (SIMULATED PLUMBING LINE) ASSEMBLY		
	1	SK2-5085-155-1	SIMULATED PLUMBING LINE ASSEMBLY		
	1	SK2-5085-154-1	VACUUM JACKET CLOSEOUT (INLET) ASSEMBLY		
	1	SK2-5085-153-1	INLET TUBE ASSEMBLY		
	16	SK2-5085-151-1	SUPPORT STRAP ASSEMBLY		
	1	SK2-5085-141-1	MLI - INSTALLATION		
	2	SK2-5085-140-1	VACUUM JACKET HEAD ASSEMBLY		
	1	SK2-5085-139-1	LH_2 PRESSURE VESSEL ASSEMBLY		
		-16	PRESSURE TAP	5	.125 OD CRES HYPODERMIC TUBING
		-15	O RING	5	VITON
	AS REQD	-14	LOCKING WIRE	SK2-5085-141	.020 DIA CRES WIRE [18]
	AS REQD	-13	SIMULATED SEAL VENT LINE	SK2-5085-141	.020 DIA CRES WIRE [18]
	1	-12	PIN - SPRING 7/32 DIA	6	1.10 LG MAKE FROM MS 16562-249
	1	-11	TUBE	6	1.00 DIA × .75 LG ALUM BAR
1		-10	PLATE	C2-4	.19 × 2.00 × 4.40 ALUM. SHEET [1]
1		-9	TRUNNION	A2-4	2.50 DIA × 5.55 ALUM. BAR [2]
1		-8	PLATE	B1-4	.19 × 4.40 × 4.40 ALUM. SHEET [1]
4		-7	PLATE	C4-4	.19 × 1.70 × 5.10 ALUM. SHEET [1]
-	4	-6	ATTACHMENT FITTING ASSEMBLY	A4-4	[3] [4]
	8	-5	SPLICE PLATE	C5-4	.16 × 1.20 × 16.80 ALUM. SHEET [1]
	4	-4	PLATE - OUTER JOINT	D5-4	.10 × 3.90 × 79.0 ALUM. SHEET [1]
	4	-3	PLATE - INNER JOINT	D5-4	.10 × 3.50 × 80.0 ALUM. SHEET [1]
	4	-2	SKIN - SEALING	D3-4	.050 × 5.60 × 82.0 ALUM. SHEET [1]
	-	-1	HALF SCALE LH_2 TEST MODEL ASSEMBLY	-2	[5]

PARTS LIST

QTY REQD -1	PART OR IDENTIFYING NUMBER	NOMENCLATURE OR DESCRIPTION	MATERIAL AND SPECIFICATION
32	BACN10JC6CM	NUT	
32	BACB30LJ6U11	BOLT 3/8 DIA	
24	AN960D416L	WASHER	
208	AN960D616L	WASHER	
16	BACB30LJ4U20	BOLT 1/4 DIA	
8	BACB30LJ4U5	BOLT 1/4 DIA	
16	BACB30LJ6U20	BOLT 3/8 DIA	
32	BACB30LJ6U17	BOLT 3/8 DIA	
160	BACB30LT6U15	BOLT 3/8 DIA	
16	MS16562-249	PIN - SPRING 7/32 DIA	
24	13705E-048	ANCHOR NUT - FLOATING, .2500-28 UNJF-3B THREAD	[8] [6]
208	13705E-064	ANCHOR NUT - FLOATING .3750-24 UNJF-3B THREAD	[8] [6]

APPLICATION | FASTENER CODES

DIMENSIONING & TOLERANCING PER ANSI (USASI) Y14.5
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES: ANGLES ± 1/2°
DECIMALS .XX ± .02
DECIMALS .XXX ± .010
RIVET & BOLT EDGE MARGIN ± .05
BEND RADII ± .01 ON .03 & .03 ± .03 ON .06 & GREATER
SHEET METAL CORNER RADII INT .10 .19/.10 EXT .22 .25/.00

CONTRACT NUMBER NAS 3-15848
DRN D.L. BARCLAY 7-18-73
ENGR D.L. BARCLAY 9/14/73

THE BOEING COMPANY
CORPORATE OFFICES SEATTLE, WASHINGTON

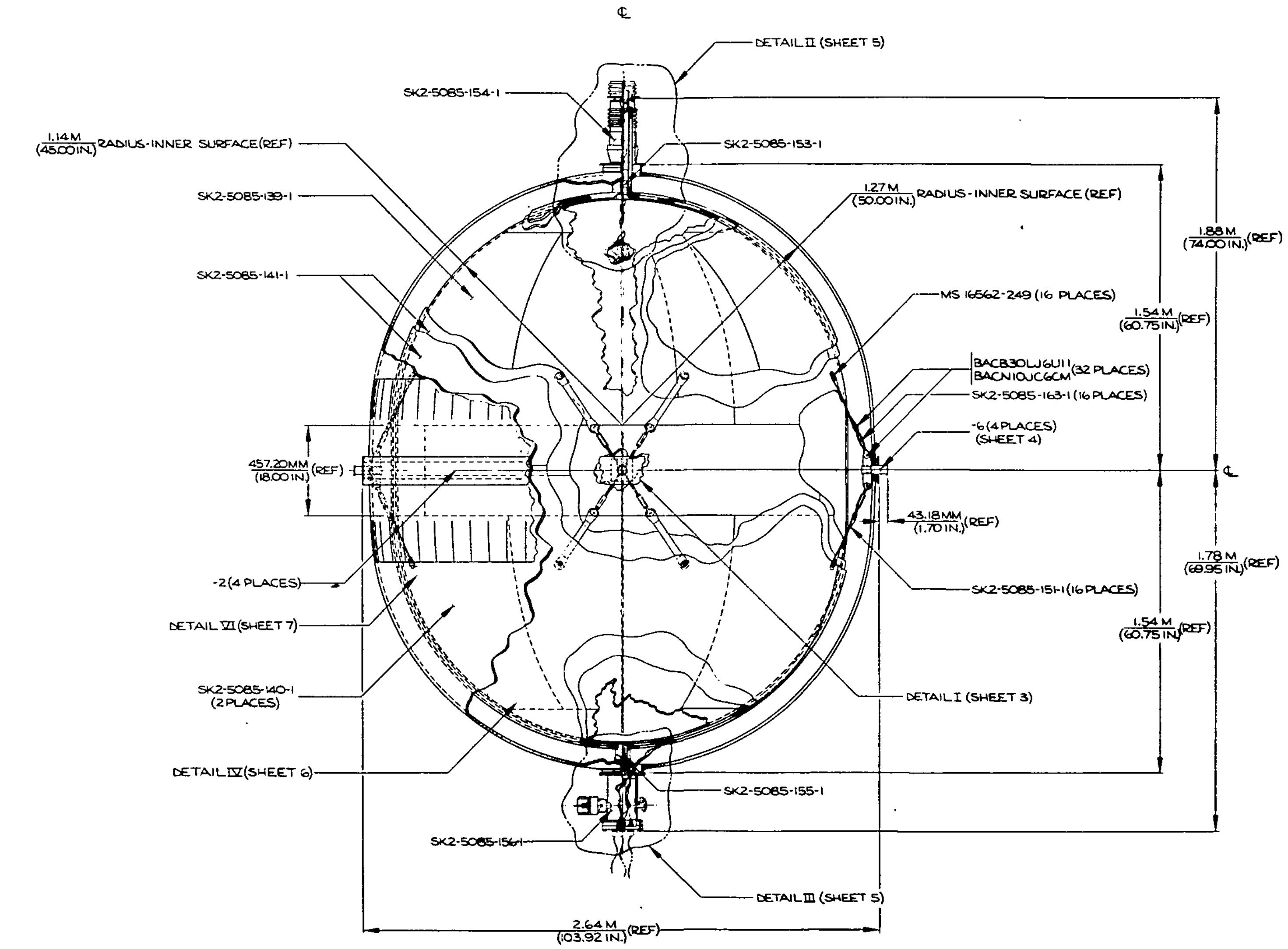
HALF SCALE LH_2 TEST MODEL ASSEMBLY

SIZE J CODE IDENT NO 81205 SK2-5085-137
SCALE NOTED SH 1 OF 4

DWG ORIG BY (ORG) 2-5520

SK2-5085-137 D

Figure D-1



-1 HALF SCALE LH$_2$ TEST MODEL ASSEMBLY

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED
	A	RE-DRAWN	8/30/74	

Figure D-2

CONTRACT NUMBER	NAS3-15848
DRN	D.M. DUNNING 8/30/74
	THE BOEING COMPANY, CORPORATE OFFICES, SEATTLE, WASHINGTON
TITLE	HALF SCALE LH$_2$ TEST MODEL ASSEMBLY
SIZE / CODE IDENT NO	J 81205 SK2-5085-137
SCALE	1/10
SH	2 OF 4
DWG ORIG BY (ORG)	2-5520

SK2-5085-137 A

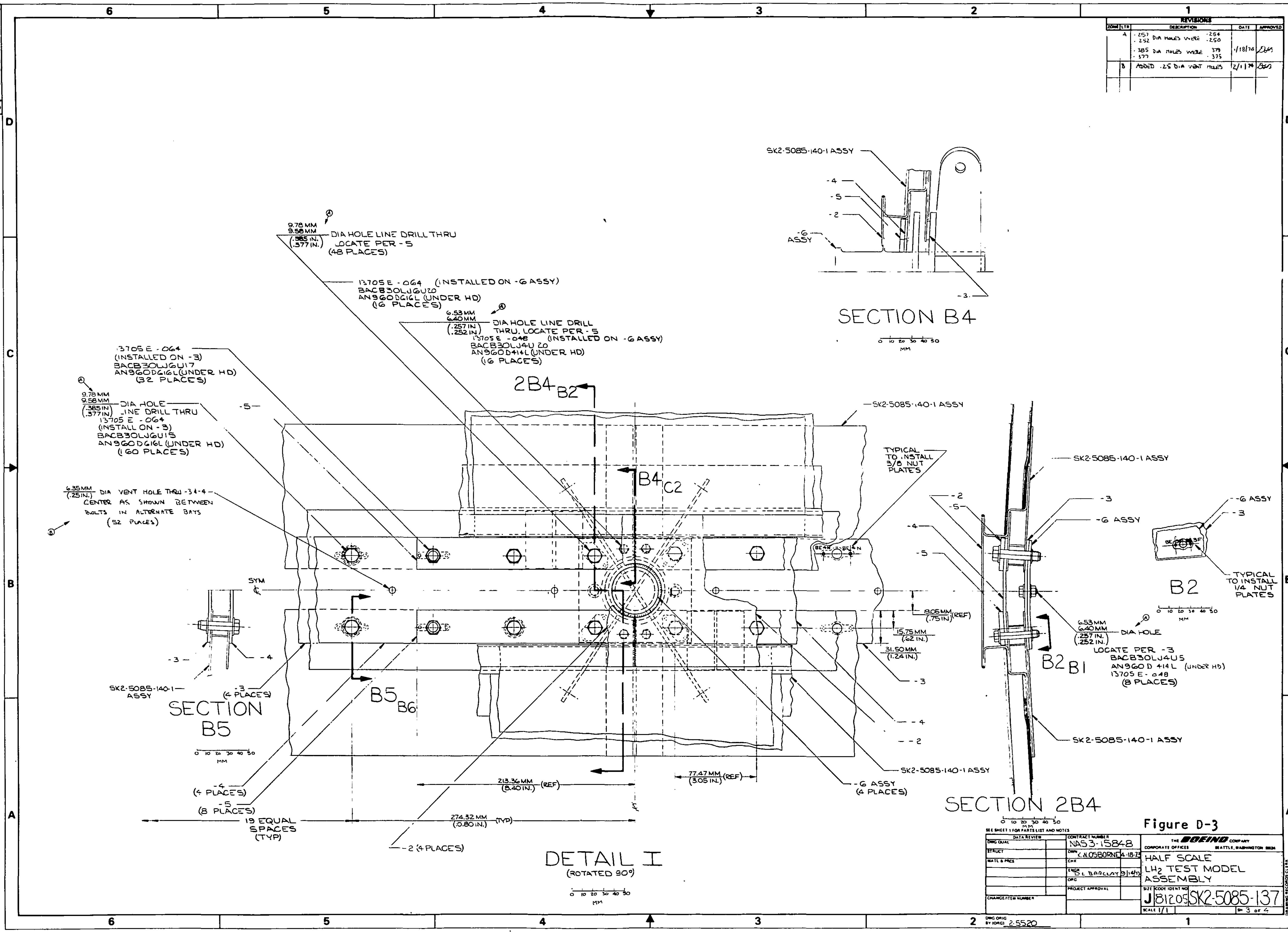
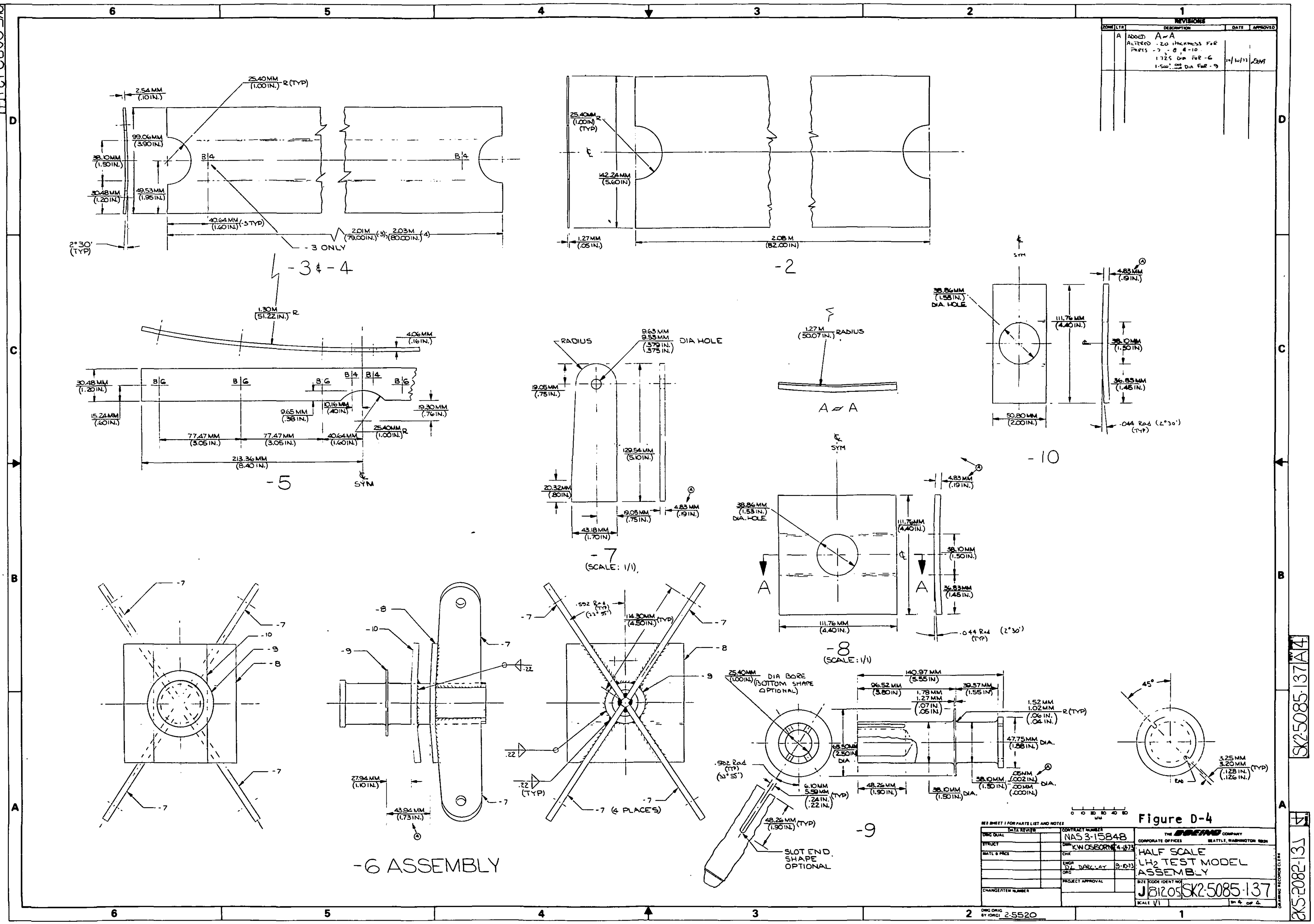
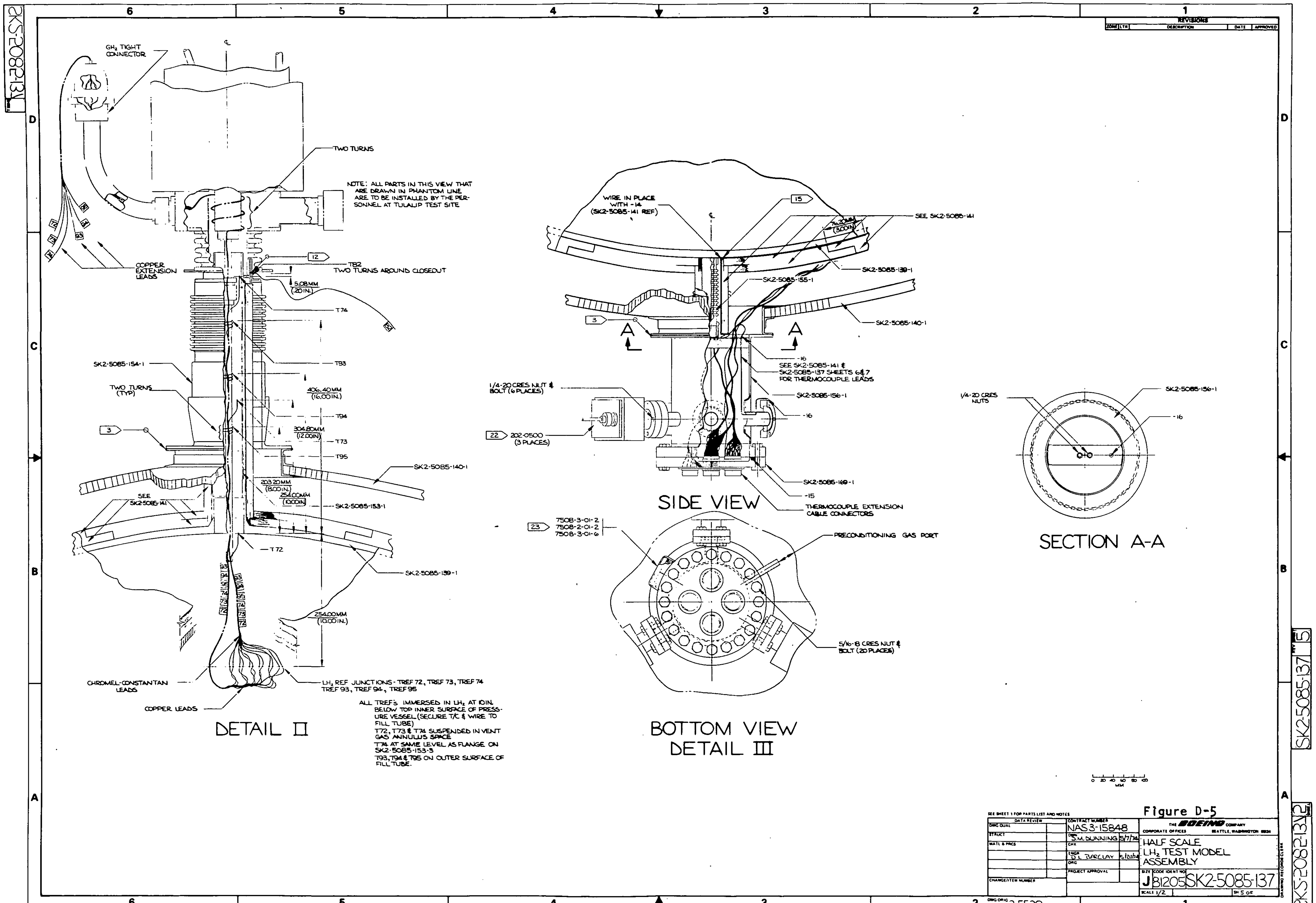

REVISIONS
ZONE LTR DESCRIPTION DATE APPROVED
A .257 .252 DIA HOLES WERE .254 .250
.385 .377 DIA HOLES WERE .379 .375
B ADDED .25 DIA VENT HOLES
SK2-5085-140-1 ASSY
-4
-5
-2
-6 ASSY
-3
SECTION B4
9.78 MM 9.58 MM (.385 IN.) (.377 IN.) DIA HOLE LINE DRILL THRU LOCATE PER -5 (48 PLACES)
13705 E -064 (INSTALLED ON -6 ASSY) BACB30LU6U20 AN960D616L (UNDER HD) (16 PLACES)
6.53 MM 6.40 MM (.257 IN) (.252 IN) DIA HOLE LINE DRILL THRU, LOCATE PER -5
13705 E -048 (INSTALLED ON -6 ASSY) BACB30LU4U20 AN960D416L (UNDER HD) (16 PLACES)
13705 E -064 (INSTALLED ON -3) BACB30LU6U17 AN960D616L (UNDER HD) (32 PLACES)
9.78 MM 9.58 MM (.385 IN) (.377 IN) DIA HOLE LINE DRILL THRU
13705 E -064 (INSTALL ON -3) BACB30LU6U15 AN960D616L (UNDER HD) (160 PLACES)
6.35 MM (.25 IN.) DIA VENT HOLE THRU -3 & -4 CENTER AS SHOWN BETWEEN BOLTS IN ALTERNATE BAYS (52 PLACES)
2B4 B2
B4 C2
TYPICAL TO INSTALL 3/8 NUT PLATES
SYM ℄
SECTION B5
B5 B6
-4 (4 PLACES)
-5 (8 PLACES)
-3 (4 PLACES)
19 EQUAL SPACES (TYP)
213.36 MM (8.40 IN.) (REF)
274.32 MM (10.80 IN.) (TYP)
77.47 MM (3.05 IN.) (REF)
8.05 MM (.75 IN) (REF)
15.75 MM (.62 IN.)
31.50 MM (1.24 IN.)
-2 (4 PLACES)
-6 ASSY (4 PLACES)
DETAIL I
(ROTATED 90°)
SECTION 2B4
B2 B1
B2
TYPICAL TO INSTALL 1/4 NUT PLATES
6.53 MM 6.40 MM (.257 IN.) (.252 IN.) DIA HOLE LOCATE PER -3
BACB30LU4U5 AN960D 416L (UNDER HD) 13705 E -048 (8 PLACES)
MM
CONTRACT NUMBER NAS3-15848
DRN C.N. OSBORNE 4-18-73
ENGR S.L. BARCLAY
THE BOEING COMPANY
HALF SCALE LH2 TEST MODEL ASSEMBLY
J 81205 SK2-5085-137
SCALE 1/1 SH 3 OF 4
SK2-5085-137 B3

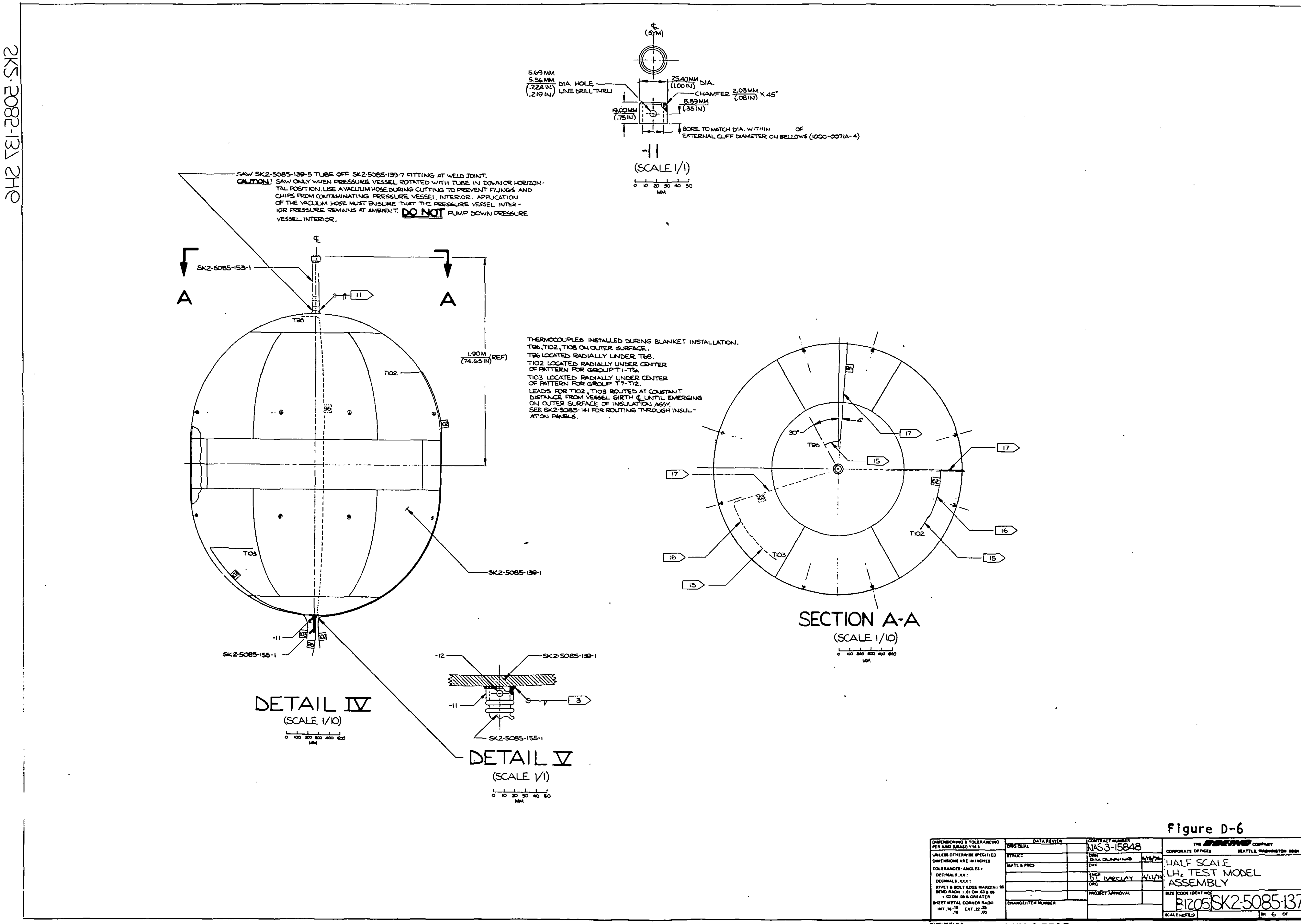
Figure D-3


REVISIONS
A ADDED A-A
-3 & -4
-2
-5
-7 (SCALE: 1/1)
A-A
-10
-8 (SCALE: 1/1)
-6 ASSEMBLY
-9
SLOT END SHAPE OPTIONAL
25.40MM (1.00IN.) DIA BORE (BOTTOM SHAPE OPTIONAL)
-3 ONLY
RADIUS
DIA HOLE
CONTRACT NUMBER NAS3-15848
KW OSBORNE
DL BARCLAY
THE BOEING COMPANY
CORPORATE OFFICES SEATTLE, WASHINGTON
HALF SCALE LH2 TEST MODEL ASSEMBLY
J 81205 SK2-5085-137
SCALE 1/1
SH 4 OF 4
SK2-5085-137 A 4
SK2-2082-131
2-5520
Figure D-4



GH₂ TIGHT CONNECTOR
TWO TURNS
NOTE: ALL PARTS IN THIS VIEW THAT ARE DRAWN IN PHANTOM LINE ARE TO BE INSTALLED BY THE PERSONNEL AT TULALIP TEST SITE
COPPER EXTENSION LEADS
T82 TWO TURNS AROUND CLOSEOUT
5.08MM (.20IN.)
T74
T93
SK2-5085-154-1
TWO TURNS (TYP)
406.40MM (16.00IN.)
T94
304.80MM (12.00IN.)
T73
T95
SK2-5085-140-1
SEE SK2-5085-141
203.20MM (8.00IN.)
254.00MM (10.00IN.)
SK2-5085-153-1
T72
SK2-5085-139-1
254.00MM (10.00IN.)
CHROMEL-CONSTANTAN LEADS
COPPER LEADS
LH₂ REF JUNCTIONS - TREF 72, TREF 73, TREF 74 TREF 93, TREF 94, TREF 95
ALL TREF'S IMMERSED IN LH₂ AT 10IN. BELOW TOP INNER SURFACE OF PRESSURE VESSEL (SECURE T/C & WIRE TO FILL TUBE)
T72, T73 & T74 SUSPENDED IN VENT GAS ANNULUS SPACE
T74 AT SAME LEVEL AS FLANGE ON SK2-5085-153-3
T93, T94 & T95 ON OUTER SURFACE OF FILL TUBE.
DETAIL II
WIRE IN PLACE WITH -14 (SK2-5085-141 REF)
15
SEE SK2-5085-141
76.20MM (3.00IN.)
SK2-5085-139-1
SK2-5085-155-1
SK2-5085-140-1
3
A
A
-16
SEE SK2-5085-141 & SK2-5085-137 SHEETS 6 & 7 FOR THERMOCOUPLE LEADS
1/4-20 CRES NUT & BOLT (6 PLACES)
SK2-5085-156-1
-16
22
202-0500 (3 PLACES)
SK2-5085-169-1
-15
THERMOCOUPLE EXTENSION CABLE CONNECTORS
SIDE VIEW
23
7508-3-01-2
7508-2-01-2
7508-3-01-6
PRECONDITIONING GAS PORT
5/16-8 CRES NUT & BOLT (20 PLACES)
BOTTOM VIEW
DETAIL III
1/4-20 CRES NUTS
SK2-5085-156-1
-16
SECTION A-A
0 20 40 60 80 100
MM
REVISIONS
ZONE LTR DESCRIPTION DATE APPROVED
SEE SHEET 1 FOR PARTS LIST AND NOTES
CONTRACT NUMBER NAS3-15848
DWN S.M. DUNNING 5/7/74
ENGR D.L. BARCLAY
THE BOEING COMPANY
CORPORATE OFFICES SEATTLE, WASHINGTON
HALF SCALE LH₂ TEST MODEL ASSEMBLY
J 81205 SK2-5085-137
SCALE 1/2
SH 5 OF
DWG ORIG BY (ORG) 2-5520
SK2-5085-137
2KS-2082-13V

Figure D-5



5.69 MM
5.56 MM DIA HOLE
(.224 IN) LINE DRILL THRU
(.219 IN)
25.40 MM DIA.
(1.00 IN)
CHAMFER 2.03 MM (.08 IN) X 45°
8.89 MM
(.35 IN)
19.00 MM
(.75 IN)
BORE TO MATCH DIA. WITHIN OF
EXTERNAL CUFF DIAMETER ON BELLOWS (1000-0071A-4)
-11
(SCALE 1/1)
SAW SK2-5085-139-5 TUBE OFF SK2-5085-139-7 FITTING AT WELD JOINT.
CAUTION: SAW ONLY WHEN PRESSURE VESSEL ROTATED WITH TUBE IN DOWN OR HORIZONTAL POSITION. USE A VACUUM HOSE DURING CUTTING TO PREVENT FILINGS AND CHIPS FROM CONTAMINATING PRESSURE VESSEL INTERIOR. APPLICATION OF THE VACUUM HOSE MUST ENSURE THAT THE PRESSURE VESSEL INTERIOR PRESSURE REMAINS AT AMBIENT. DO NOT PUMP DOWN PRESSURE VESSEL INTERIOR.
SK2-5085-153-1
A
A
T96
T102
1.90 M (REF)
(74.63 IN)
T103
SK2-5085-139-1
-11
SK2-5085-155-1
DETAIL IV
(SCALE 1/10)
-12
SK2-5085-139-1
-11
SK2-5085-155-1
DETAIL V
(SCALE 1/1)
THERMOCOUPLES INSTALLED DURING BLANKET INSTALLATION.
T96, T102, T103 ON OUTER SURFACE.
T96 LOCATED RADIALLY UNDER T68.
T102 LOCATED RADIALLY UNDER CENTER OF PATTERN FOR GROUP T1-T6.
T103 LOCATED RADIALLY UNDER CENTER OF PATTERN FOR GROUP T7-T12.
LEADS FOR T102, T103 ROUTED AT CONSTANT DISTANCE FROM VESSEL GIRTH ℄ UNTIL EMERGING ON OUTER SURFACE OF INSULATION ASSY.
SEE SK2-5085-141 FOR ROUTING THROUGH INSULATION PANELS.
30°
4°
T96
T102
T103
SECTION A-A
(SCALE 1/10)
NAS3-15848
D.M. DUNNING
D.I. BARCLAY
THE BOEING COMPANY
SEATTLE, WASHINGTON
HALF SCALE
LH2 TEST MODEL
ASSEMBLY
81205
SK2-5085-137
SH 6
2-5520

Figure D-6

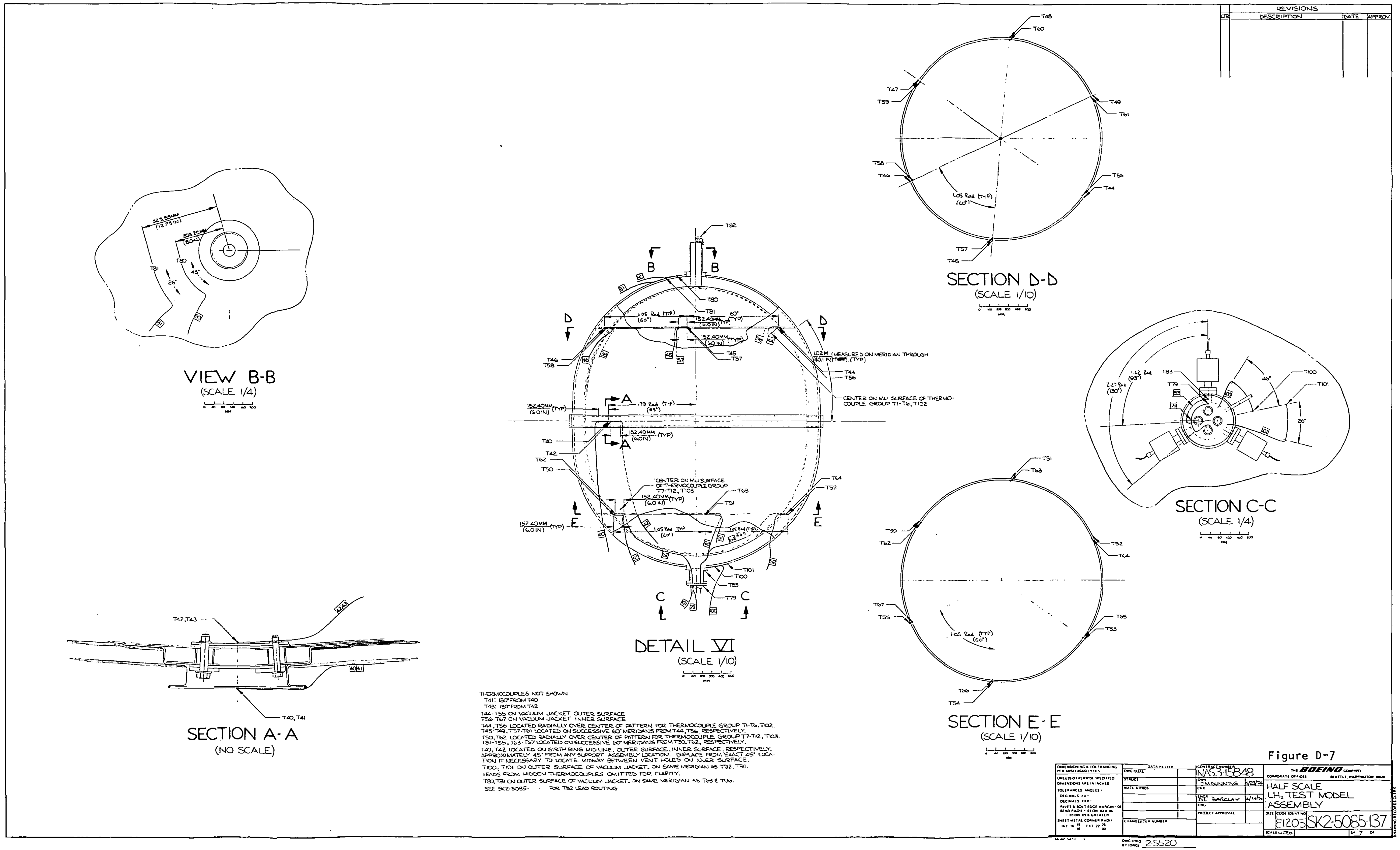
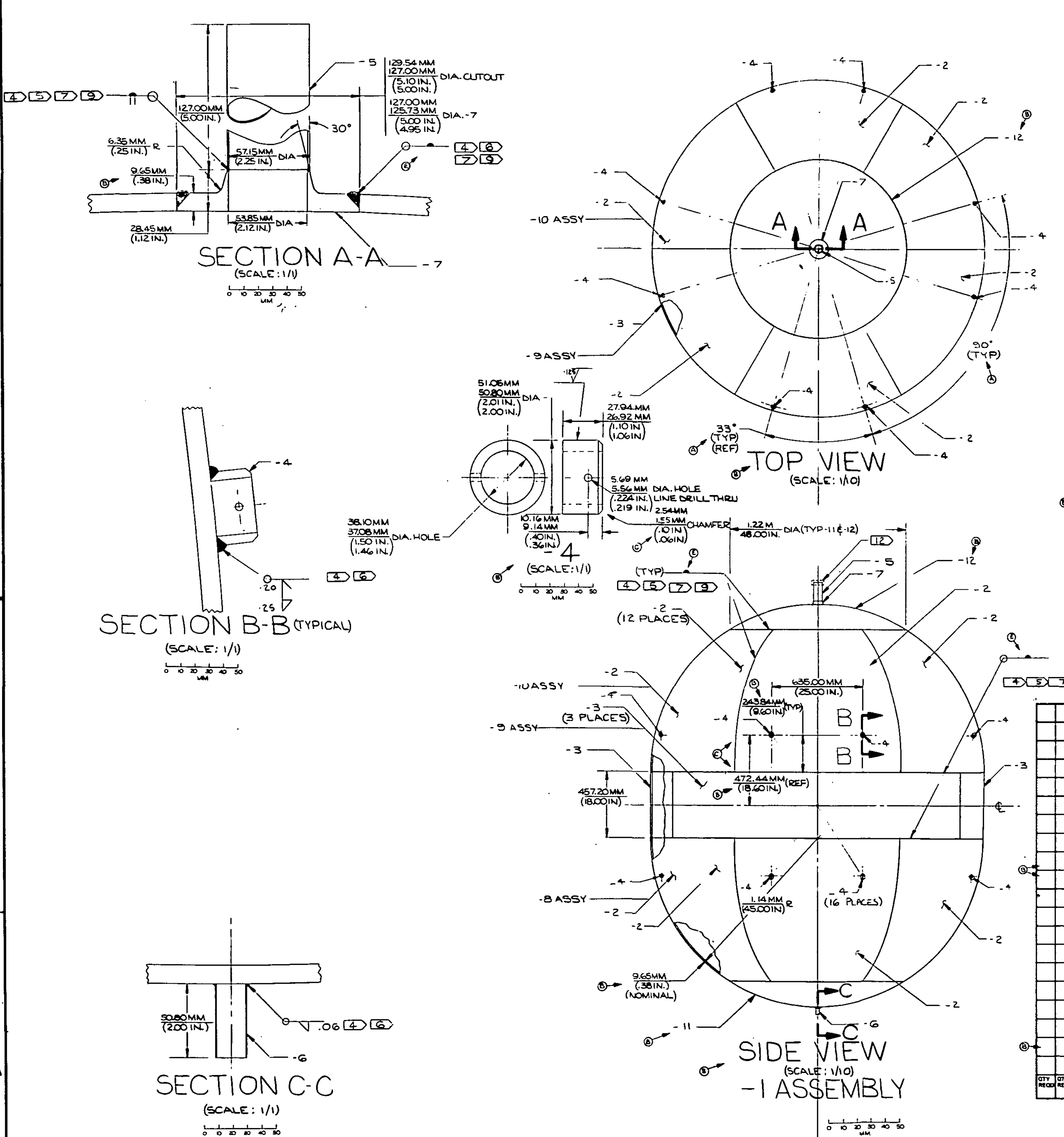

REVISIONS
VIEW B-B
(SCALE 1/4)
SECTION A-A
(NO SCALE)
DETAIL VI
(SCALE 1/10)
SECTION D-D
(SCALE 1/10)
SECTION C-C
(SCALE 1/4)
SECTION E-E
(SCALE 1/10)
THERMOCOUPLES NOT SHOWN
T41: 180° FROM T40
T43: 180° FROM T42
T44-T55 ON VACUUM JACKET OUTER SURFACE
T56-T67 ON VACUUM JACKET INNER SURFACE
T44, T56 LOCATED RADIALLY OVER CENTER OF PATTERN FOR THERMOCOUPLE GROUP T1-T6, T102.
T45-T49, T57-T61 LOCATED ON SUCCESSIVE 60° MERIDANS FROM T44, T56, RESPECTIVELY.
T50, T62 LOCATED RADIALLY OVER CENTER OF PATTERN FOR THERMOCOUPLE GROUP T7-T12, T103.
T51-T55, T63-T67 LOCATED ON SUCCESSIVE 60° MERIDANS FROM T50, T62, RESPECTIVELY.
T40, T42 LOCATED ON GIRTH RING MID LINE, OUTER SURFACE, INNER SURFACE, RESPECTIVELY, APPROXIMATELY 45° FROM ANY SUPPORT ASSEMBLY LOCATION. DISPLACE FROM EXACT 45° LOCATION IF NECESSARY TO LOCATE MIDWAY BETWEEN VENT HOLES ON INNER SURFACE.
T100, T101 ON OUTER SURFACE OF VACUUM JACKET, ON SAME MERIDIAN AS T32, T91.
LEADS FROM HIDDEN THERMOCOUPLES OMITTED FOR CLARITY.
T80, T81 ON OUTER SURFACE OF VACUUM JACKET, ON SAME MERIDIAN AS T63 & T96.
SEE SK2-5085- - FOR T82 LEAD ROUTING
CONTRACT NUMBER NAS3-15848
THE BOEING COMPANY
CORPORATE OFFICES SEATTLE, WASHINGTON
DWN DM DUNNING 4/23/74
ENGR DL BARCLAY
HALF SCALE
LH2 TEST MODEL
ASSEMBLY
SIZE E CODE IDENT NO 81205 SK2-5085-137
SCALE NOTED SH 7
DWG ORIG BY (ORG) 2-5520

Figure D-7



REVISIONS

ZONE	LTR	DESCRIPTION	DATE	APPROVED
	A	1. REVISED NOTES AND TEST REQUIREMENTS 2. ADDED FOUR -4 FITTINGS 3. VESSEL WALL THICKNESS WAS .50	3/21/73	
	B	1. ADDED -11 & -12 CAPS, 15, AND TOLERANCES ON -4 FTG 2. ALTERED PROOF PRESSURE, GENERAL TOLERANCES, -4 LOCATING DIMENSIONS, AND -2 GORE QUANTITY	6/13/73	
	C	1. ALTERED 4, 10, AND -4 FTG AND LOCATING DIMENSIONS 2. ADDED 16	6/28/73	
	D	ALTERED 3	9/18/73	
	E	DELETED J WELD SYMBOL	10/3/73	

NOTES

~~SPECIFICATIONS AND STANDARDS FOR THE CONTROL OF MANUFACTURING OPERATIONS (AS APPLICABLE): SURFACE ROUGHNESS SYMBOLS PER BACD 2007 — PART MARKING PER BAC 5307 — FORM, STRAIGHTEN & SUBSEQUENT PARTS PER BAC 5300 — FINISH CODES PER DOCUMENT D3-6000 — MATERIAL SUBSTITUTIONS & EQUIVALENTS PER BAC — RIVET INSTALLATION & SYMBOLS PER BAC~~

1. THIS PRESSURE VESSEL WILL BE USED FOR LIQUID HYDROGEN CONTAINMENT IN AN EVACUATED MULTILAYER INSULATION SYSTEM TEST MODEL WHERE IT FORMS THE INNER SURFACE OF THE INSULATION VACUUM ANNULUS. MAXIMUM INTERNAL PRESSURE DURING TESTS WILL BE 20 PSIA.
2. 6061 CONDITION 'O' ALUMINUM ALLOY PLATE PER QQ-A-250/11.
3. (D) 6061 T6 ALUMINUM ALLOY TUBE per QQ-A-200/9C or WW-T-700/60
4. (C) WELD PER MIL-W-8604. INSPECT PER 16. EDGE PREPARATION AS REQUIRED. FILLER WIRE ER 4043 PER QQ-R-566 TYPE 4043 OR MIL-E-16053 TYPE 4043.
5. FIRST PASS GTA. SUBSEQUENT PASSES MAY BE GMA.
6. GTA
7. MAXIMUM OVERBEAD 0.06
8. CLEAN INTERIOR OF HEADS AND CYLINDER PER 10 PRIOR TO FINAL CLOSEOUT WELD AT THE GIRTH.
9. WELD SEAM MUST BE HELIUM LEAK TIGHT.
10. (C) CLEAN PER MIL-P-52211 (CE)
11. GIRTH WELD IN "AS WELDED" CONDITION
12. A SUITABLE CAP FOR PREVENTING CONTAMINATION OF THE VESSEL INTERIOR SHALL BE INSTALLED OVER THE OUTLET TUBE. THIS CAP SHALL BE IN PLACE AT ALL TIMES EXCEPT DURING MANUFACTURING OPERATIONS AND TESTING.
13. HEAD MAY BE FABRICATED BY SPINNING OR AS A WELDED GORE ASSEMBLY
14. HEAT TREAT TO T6
15. (B) TOLERANCE ON PRESSURE VESSEL DIAMETER ±.38
16. (C) WELD QUALITY SHALL BE DETERMINED BY 100 PERCENT VISUAL AND RADIOGRAPHIC INSPECTION. RADIOGRAPHIC INSPECT PER MIL-STD-453 TO MEET RADIOGRAPHIC QUALITY LEVEL 2 (TABLE 1). PENETRANT INSPECTION SHALL NOT BE USED. WELD QUALITY SHALL MEET REQUIREMENTS SPECIFIED FOR CLASS A WELD IN BAC 5975 TABLES XI AND XII.

(A) **TEST REQUIREMENTS**

THE SUPPLIER SHALL TEST THE PRESSURE VESSEL AND PROVIDE CERTIFIED TEST REPORTS TO SHOW COMPLIANCE WITH THE REQUIREMENTS LISTED BELOW. TEST SEQUENCE IS AS FOLLOWS:

1.0 COLD SHOCK

COLD SHOCK WITH LIQUID NITROGEN

NOTE: REMOVE CAP 12 DURING TEST

2.0 INTERNAL PROOF PRESSURE TEST

(B) HYDROSTATICALLY PROOF PRESSURE TEST AT ROOM TEMPERATURE TO 40 PSI WITH DEIONIZED WATER

3.0 WELD SEAM TEST CHECK

HELIUM LEAK CHECK WELD SEAMS INCREMENTALLY USING A VACUUM CUP ARRANGEMENT CONNECTED TO A LEAK DETECTOR. PRESSURIZE VESSEL INTERIOR TO 5 PSI WITH HELIUM/AIR MIXTURE AT ROOM TEMPERATURE. AFTER COMPLETE CHECK OF WELD SEAMS REPAIR AS NECESSARY. REPEAT TESTS 1.0, 2.0 AND 3.0 AFTER REPAIRS.

PARTS LIST

QTY REQD	QTY REQD	QTY REQD -10	QTY REQD -9	QTY REQD -8	QTY REQD -1	CODE IDENT NO	PART OR IDENTIFYING NUMBER	NOMENCLATURE OR DESCRIPTION	ZONE	MATERIAL AND SPECIFICATION	HT TR	FINISH	PT MK	SER BASE NUMBER	REV LTR
		1	-	-	-		-12	CAP		2					
		-	-	1	-		-11	CAP		2					
		-	-	-	1		-10	HEAD ASSY		8 13 14					
		-	-	-	1		-9	CYLINDER ASSY		6 14					
		-	-	-	1		-8	HEAD ASSY		8 13 14					
		1	-	-	-		-7	FLANGE		2					
		-	-	-	1		-6	TUBE		.875 DIA × .035 WALL 3					
		-	-	-	1		-5	TUBE		2.25 DIA × .035 WALL 3					
		8	-	8	-		-4	FITTING		2					
		-	3	-	-		-3	PLATE		2					
		6	-	6	-		-2	GORE		2					
		-	-	-	-		-1	VESSEL ASSY		15					

DIMENSIONING & TOLERANCING PER ANSI (USASI) Y14.5
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES: ANGLES ± 1°
DECIMALS .XX ± .125
DECIMALS .XXX ±

CONTRACT NUMBER NAS3-15848
DWN K.W. OSBORNE 11-72
ENGR L. BARCLAY 12-8-72

THE BOEING COMPANY
CORPORATE OFFICES SEATTLE, WASHINGTON

LH$_2$ PRESSURE VESSEL ASSEMBLY HALF SCALE TEST MODEL

J 81205 SK2-5085-139

FASTENER CODES

APPLICATION

DWG ORIG BY (ORG) 2-5520

Figure D-8

SK2-2082-140-11

ASSEMBLY AND QUALIFICATION PROCEDURE

- 1.0 ASSEMBLE GORES -3, STRIPS -5, FLANGE -14, AND RING ASSY -19 PER [8]
- 2.0 HELIUM LEAK CHECK BONDED ASSY AT 66.6 mN/m² (5×10^{-4} TORR) OR BETTER
- 3.0 FILL SKIN GAP FLUSH PER [19]
- 4.0 BOND STRIPS -6 PER [8]. FAIR JOINT STEPS PER [18]. BOND DOUBLERS -21 AND SPLICE STRIPS -23 PER [8]. FAIR JOINT STEPS PER [18].
- 5.0 HELIUM LEAK CHECK (2.0)
- 6.0 APPLY METLBOND 329 TO THE OUTER SURFACE OF THE INNER SKIN PER [4] & ASSEMBLE CORE -2. POT CORE AT APEX AND GIRTH PER [15]. SPLICE CORE SEAMS WITH [5] WIRE CORE TOGETHER AT SEAMS WITH .13cm (.051in) DIA CRES WIRE THEN BOND PER [4] USING CAUL PLATES BETWEEN THE CORE & VACUUM BAG.
- 7.0 APPLY METLBOND TO THE OUTER SURFACE OF THE CORE -2. PLACE ONE LAYER OF POSITIONING CLOTH, AF 3306 (3M Co) OVER THE METLBOND. PREPARE GORES -4 AND BOND TO CORE PER [4]. FILL SKIN GAP FLUSH PER [19]
- 8.0 BOND STRIPS -7, DOUBLERS -22, SPLICE STRIPS -24, AND RING SEGMENTS -15 TO GORES & RING SEGMENTS -15 TO FLANGE -14 PER [8]
- 9.0 HELIUM LEAK CHECK PER (2.0)
- 10.0 APPLY EA934 PER [14] TO FAYING SURFACES BETWEEN -12 PLATES, -17 SPLICE STRIPS & RING ASSEMBLY -19, AND -13 PLATES, -5 STRIPS, -18 SPLICE STRIPS, RING ASSEMBLY -19 & BOND PER [14].
- 11.0 DRILL .377 $^{.385}_{.377}$ & .252 $^{.257}_{.252}$ DIA. HOLES IN PLATES -12 & -13. BOND -10 SPACERS IN PLACE PER [21]

NOTES

1. SPECIFICATIONS AND STANDARDS FOR THE CONTROL OF MANUFACTURING OPERATIONS (AS APPLICABLE):
   SURFACE ROUGHNESS SYMBOLS PER BACD 2007 — PART MARKING PER BAC 5307
   WELDING AND BRAZING SYMBOLS PER BACD 2022 — BOLT & NUT INSTALLATION PER BAC 5009
   FORM, STRAIGHTEN & FIT METAL PARTS PER BAC 5300 — FINISH CODES PER DOCUMENT D2-5000
   MATERIAL SUBSTITUTIONS & EQUIVALENTS PER BAC 5005 — RIVET INSTALLATION & SYMBOLS PER BAC 5004

[21] CLEAN PER HYSOL BULLETIN G1 600. BOND WITH EA 934 (HYSOL DIVISION, THE DEXTER CORP) .05 MAX ADHESIVE FILLET.

[20] CLEAN METAL DETAILS PRIOR TO BONDING AS FOLLOWS
a) CHEM CLEAN
b) SAND WITH COURSE GRIT (≈80) SAND PAPER
c) SOLVENT CLEAN WITH BMS 11-7

[19] FILL SKIN GAP WITH XA-3919 ADHESIVE (3M CO.)

[18] FAIR JOINT STEP WITH 0.25 IN. WIDE FILLET USING EA 934 ADHESIVE (HYSOL DIVISION THE DEXTER CORP)

[17] CLEAN METAL DETAILS AS FOLLOWS:
a) VAPOR DEGREASE FLEX-CORE.
b) CHEM CLEAN ALL METAL DETAILS EXCEPT CORE.
c) SAND WITH 400 GRIT SANDPAPER ALL SURFACES NOT PRIMED OR BONDED IMMEDIATELY AFTER CHEM CLEANING.
d) SOLVENT CLEAN ALL PARTS WITH BMS 11-7 PRIOR TO PRIMING OR BONDING

[16] CURE BOND AT 450°K (350°F) FOR 1 HOUR. MINIMUM CURE PRESSURE 101.4 kN/m² (14.7 PSI) [VACUUM PRESSURE]. MAXIMUM CURE PRESSURE 344.7 kN/m² (50 PSI)

[15] POT OUTER 0.10 IN CORE SURFACES OVER THIS LENGTH WITH [5]

[14] CLEAN PER [20]. BOND WITH EA 934 (HYSOL DIVISION, THE DEXTER CORP) CLAMP PARTS TOGETHER FOR 8 HRS AT RT.

[13] FUSION WELD PER BAC 5935, CLASS SP (VACUUM TIGHT)

[11] 6061-T6 ALUM SHEET PER QQ-A-250/11

[10] 1100-H18 ALUM FOIL PER QQ-A-250/1

[9] 2024 T3 ALUM TUBE PER QQ-A-200/3

[8] CLEAN PER [17] AND BOND WITH XA-3919 (3M Co) APPLY BY BRUSH COATING BOTH SURFACES. AIR DRY FOR 15 MIN. FOLLOWED BY A 45 MIN. DRYING CYCLE AT 380°K (225°F). CURE BOND PER [16].

7 CLEAN PER BAC 5514, ALL METAL PARTS AFTER MACHINING.

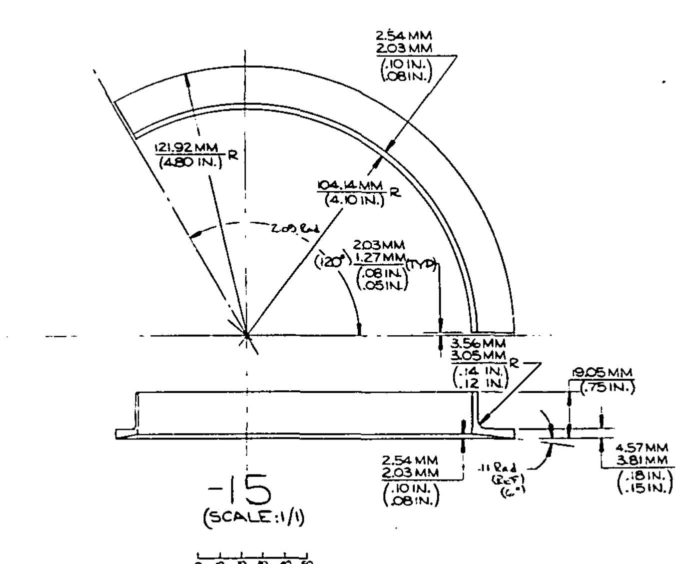
6 ALL RAW MATERIALS SUBASSEMBLIES & ASSEMBLIES SHALL BE PROTECTED FROM OIL & PARTICLE CONTAMINATION. ASSEMBLY SHALL BE DONE IN A DUST FREE ROOM.

[5] STRUCTURAL FOAMING ADHESIVE PER BAC 5-90, TYPE 2, CLASS 350, GRADE 50

[4] CLEAN PER [17]. PRIME WITH METLBOND 329 TYPE 2, APPLY METLBOND 329 ADHESIVE (NARMCO MATERIALS DIV., WHITTAKER CORP). CURE BOND PER [16].

[2] FLEX-CORE 5056/F40-.0014 33.6 kg/m³ (2.1 LB/FT³) ALUM HONEYCOMB. HEXCEL PRODUCTS INC.

[1] 2024-T81 ALUM PER QQ-A-250/5



-15
(SCALE: 1/1)

REVISIONS

LTR	DESCRIPTION	DATE	APPROVED
A	DELETED -9 & [3]; REVISED [4] & [8]; ADDED [15] & [16]	1/6/71	
B	REVISED [4], [8], [14], [15], [16], AND ASSEMBLY PROCEDURES 3.0, 4.0, 6.0, 7.0, & 8.0. ADDED [17], [18] & [19]. DELETED STRIP, WT -16	7/6/71	
C	DELETED -8 & -11 FILLERS; QTY REQ'D FOR -10 WAS 120	7/26/71	
D	REVISED ASSEMBLY PROCEDURE 1.0, 10.0 & 11.0; MAT'L SIZE -3 THRU -7 & -10; [9] & [14]. ADDED [20] & [21]	1/18/74	

REV STATUS SH	LTR
2	A
2	D
2	C
3	A
5	B

PARTS LIST

QTY REQD -19	QTY REQD -1	CODE IDENT NO	PART OR IDENTIFYING NUMBER	NOMENCLATURE OR DESCRIPTION	ZONE	MATERIAL AND SPECIFICATION	REV LTR
-	6		-24	SPLICE STRIP	A4-3	.012 × 2.1 × 5.25 ALUM SHEET [1]	B
-	6		-23	SPLICE STRIP	A4-3	.012 × 2.1 × 8.20 ALUM SHEET [1]	B
-	6		-22	DOUBLER-OUTER	D5-3	.012 × 17.2 × 57.0 ALUM SHEET [1]	
-	6		-21	DOUBLER-INNER	D3-3	.012 × 16.2 × 57.0 ALUM SHEET [1]	
3	-		-20	RING SEGMENT	B4-2	.050 × 4.8 × 106.0 ALUM SHEET [11]	
-	1		-19	RING ASSEMBLY	B4-2	[13]	
-	4		-18	SPLICE STRIP	B2-3	.080 × 2.0 × 5.4 ALUM SHEET [11]	
-	4		-17	SPLICE STRIP	B5-3	.080 × 2.0 × 2.2 ALUM SHEET [11]	
							B
-	3		-15	RING SEGMENT	B6-1	.750 × 9.00 × 9.00 ALUM PL [11]	
-	1		-14	FLANGE	B6-2	2.50 × 14.10 × 14.10 ALUM PLATE [11] [8]	
-	4		-13	PLATE	D3-3	.080 × 5.4 × 79.5 ALUM SHEET [11]	
-	4		-12	PLATE	D5-3	.080 × 2.2 × 80.0 ALUM SHEET [11]	
							C
-	104		-10	SPACER	B2-3	.75 DIA × .065 WALL TUBE [9]	D
							A
							C
-	12		-7	STRIP-EXTERNAL	B2-2	.012 × 80 × 2.1 ALUM STRIP [1]	D
-	12		-6	STRIP-OUTER	B2-2	.012 × 80 × 2.1 ALUM STRIP [1] [8]	D
-	12		-5	STRIP-INNER	B2-2	.003 × 80 × 2.1 ALUM FOIL [10] [8]	D
-	12		-4	SKIN GORE-OUTER	B2-2	.012 × 80 × 28.5 ALUM SHEET [1]	D
-	12		-3	SKIN GORE-INNER	B2-2	.012 × 80 × 28.5 ALUM SHEET [1]	D
-	AR		-2	CORE	B2-2	[2] [4] [5]	
-	-		-1	VACUUM JACKET ASSEMBLY			

DIMENSIONING & TOLERANCING PER ANSI (USASI) Y14.5
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES: ANGLES ± 1°
DECIMALS .XX ± .02
DECIMALS .XXX ± .005

CONTRACT NUMBER NAS3-15848
DWN K.W. OSBORNE 12-21-72
ENGR J.L. BARCLAY 12-26-72

THE BOEING COMPANY — CORPORATE OFFICES — SEATTLE, WASHINGTON

VACUUM JACKET HEAD ASSEMBLY - HALF SCALE LH₂ TEST MODEL

SIZE J — CODE IDENT NO 81205 — SK2-5085-140

SCALE NOTED

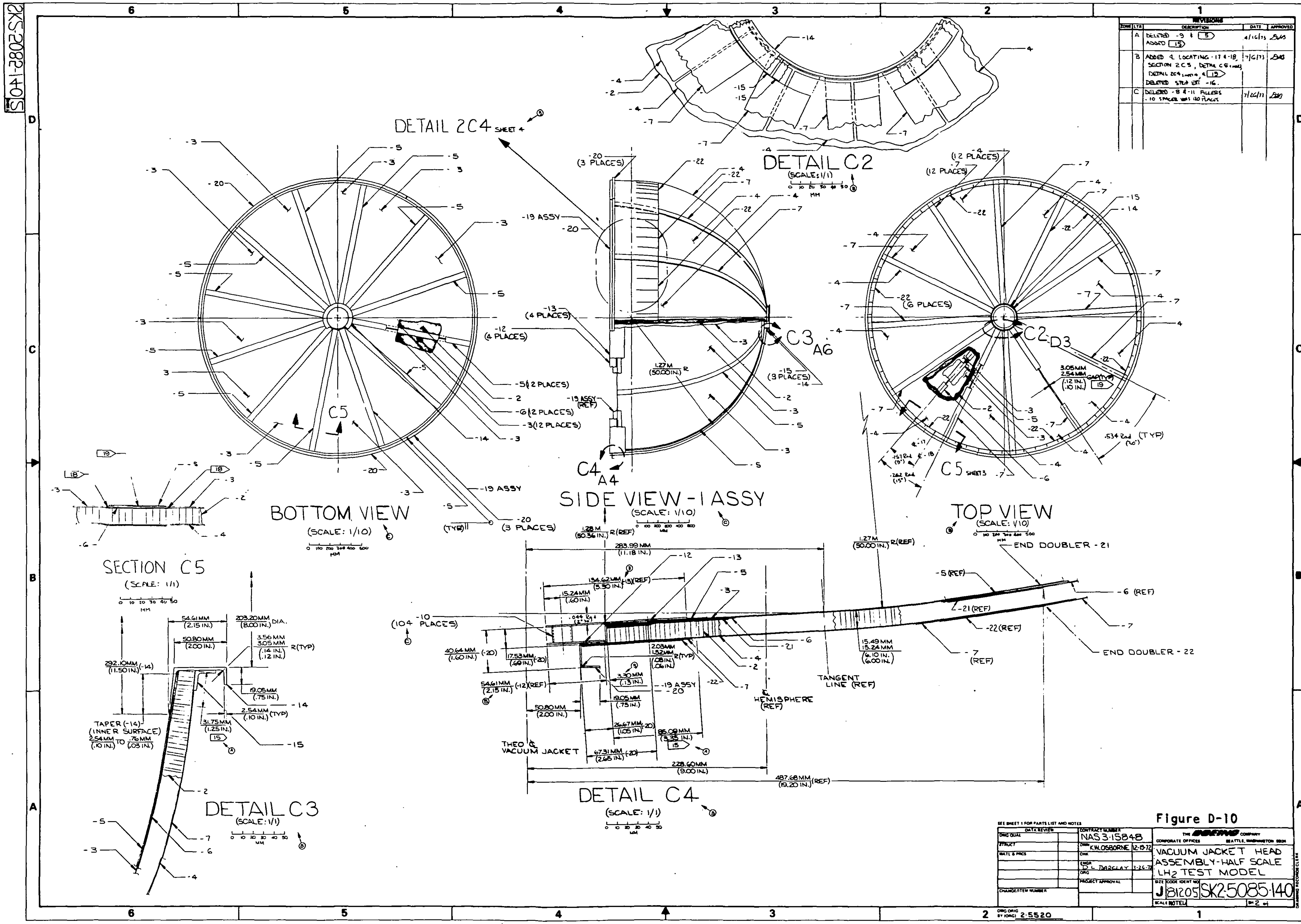
APPLICATION — FASTENER CODES

DWG ORIG BY 25520

SK2-5085-140 D

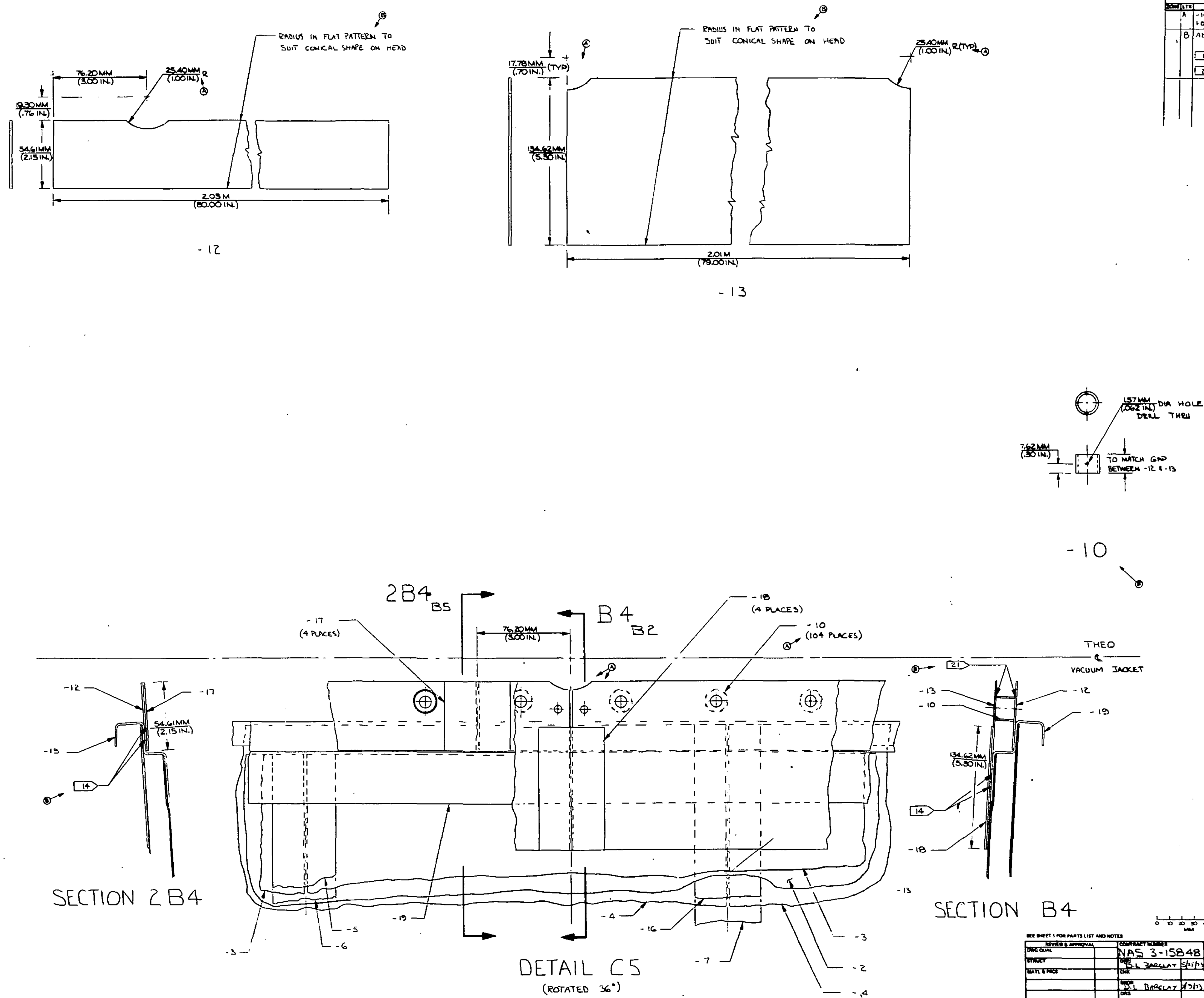
Figure D-9

SK2-2082-140-11



REVISIONS
A DELETED -9 & 5 ADDED 15
B ADDED ℄ LOCATING -17 & -18, SECTION 2C5, DETAIL 2C4, DELETED STUD ST. -16.
C DELETED -8 & -11 FILLERS -10 SPACER WAS 90 PLACES
DETAIL 2C4 SHEET 4
DETAIL C2
(SCALE: 1/1)
BOTTOM VIEW
(SCALE: 1/10)
SIDE VIEW - 1 ASSY
(SCALE: 1/10)
TOP VIEW
(SCALE: 1/10)
SECTION C5
(SCALE: 1/1)
DETAIL C3
(SCALE: 1/1)
DETAIL C4
(SCALE: 1/1)
END DOUBLER - 21
END DOUBLER - 22
TANGENT LINE (REF)
℄ HEMISPHERE (REF)
THEO ℄ VACUUM JACKET
TAPER (-14) (INNER SURFACE) 2.54MM (.10 IN.) TO .76MM (.03 IN.)
1.27M (50.00 IN.) R
1.28M (50.36 IN.) R (REF)
283.99MM (11.18 IN.)
487.68MM (19.20 IN.) (REF)
228.60MM (9.00 IN.)
203.20MM (8.00 IN.) DIA.
292.10MM (11.50 IN.) (-14)
SEE SHEET 1 FOR PARTS LIST AND NOTES
CONTRACT NUMBER NAS3-15848
K.W. OSBORNE 12-13-72
D. L. BARCLAY
THE BOEING COMPANY
CORPORATE OFFICES SEATTLE, WASHINGTON
VACUUM JACKET HEAD ASSEMBLY - HALF SCALE LH2 TEST MODEL
J 81205 SK2-5085-140
SCALE NOTED SH 2
2-5520
SK2-5085-140 C2
SK2-2082-140 S

Figure D-10



REVISIONS

LTR	DESCRIPTION	DATE	APPROVED
A	-10 SPACER WAS 120 PLACES 1.00 RAD WAS 1.12 RAD	7/12/73	
B	ADDED DETAIL -10, ADDED NOTE FOR -12 & -13; 14 WAS 8 IN 2B4; 21 WAS 14 IN B4	11/18/74	

Figure D-11

NAS 3-15848

THE BOEING COMPANY

VACUUM JACKET HEAD ASSEMBLY - HALF SCALE LH_2 TEST MODEL

D.L. BARCLAY

J 81205 SK2-5085-140

SCALE 1/1

2-5520

SK2-5085-140 B3

2K5-2082-1403

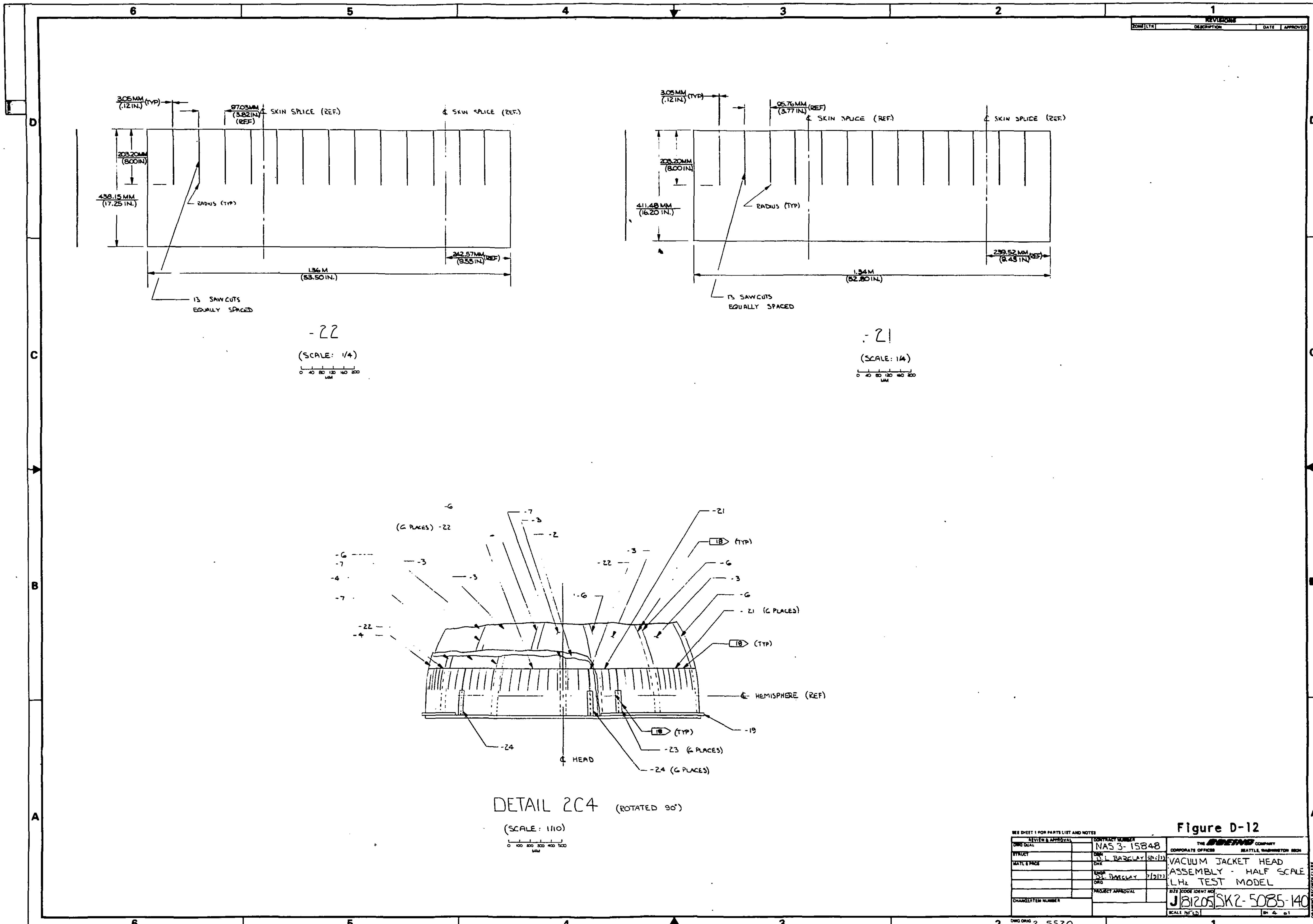
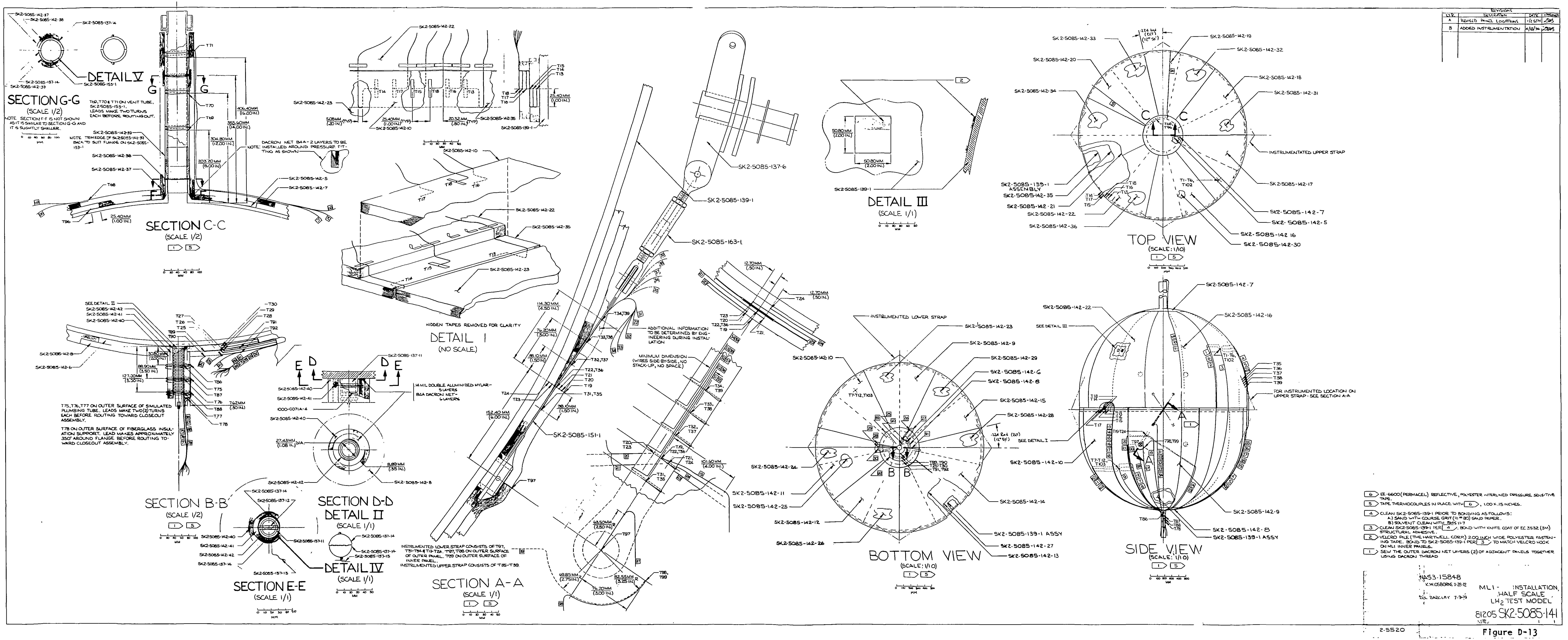

3.05MM (.12IN.) (TYP)
97.03MM (3.82IN.) (REF)
℄ SKIN SPLICE (REF.)
℄ SKIN SPLICE (REF.)
203.20MM (8.00IN.)
438.15MM (17.25 IN.)
RADIUS (TYP)
242.57MM (9.55IN.) (REF)
1.36M (53.50 IN.)
13 SAW CUTS EQUALLY SPACED
-22
(SCALE: 1/4)
3.05MM (.12IN.) (TYP)
95.76MM (3.77IN.) (REF)
℄ SKIN SPLICE (REF.)
℄ SKIN SPLICE (REF.)
203.20MM (8.00IN.)
411.48MM (16.20 IN.)
RADIUS (TYP)
239.52MM (9.43IN.) (REF)
1.34M (52.80IN.)
13 SAW CUTS EQUALLY SPACED
-21
(SCALE: 1/4)
(6 PLACES) -22
-21 (6 PLACES)
18 (TYP)
℄ HEMISPHERE (REF)
-19
-23 (6 PLACES)
-24 (6 PLACES)
℄ HEAD
DETAIL 2C4 (ROTATED 90°)
(SCALE: 1/10)
SEE SHEET 1 FOR PARTS LIST AND NOTES
CONTRACT NUMBER NAS 3-15848
DRN D.L. BARCLAY
ENGR D.L. BARCLAY
THE BOEING COMPANY
CORPORATE OFFICES SEATTLE, WASHINGTON
VACUUM JACKET HEAD ASSEMBLY - HALF SCALE LH2 TEST MODEL
SIZE J CODE IDENT NO 81205 SK2-5085-140
SCALE NOTED
DWG ORIG BY (ORG) 2-5520

Figure D-12



DETAIL V
SECTION G-G
(SCALE 1/2)
SECTION C-C
(SCALE 1/2)
DETAIL I
(NO SCALE)
HIDDEN TAPES REMOVED FOR CLARITY
DETAIL III
(SCALE 1/1)
TOP VIEW
(SCALE: 1/10)
SECTION B-B
(SCALE 1/2)
SECTION D-D
DETAIL II
(SCALE 1/1)
DETAIL IV
(SCALE 1/1)
SECTION E-E
(SCALE 1/1)
SECTION A-A
(SCALE 1/1)
BOTTOM VIEW
(SCALE: 1/10)
SIDE VIEW
(SCALE: 1/10)
6 EE-6600 (PERMACEL) REFLECTIVE, POLYESTER INTERLINED PRESSURE SENSITIVE TAPE.
5 TAPE THERMOCOUPLES IN PLACE WITH 6, 1.00 X .15 INCHES.
4 CLEAN SK2-5085-139-1 PRIOR TO BONDING AS FOLLOWS:
A.) SAND WITH COURSE GRIT (≈ #80) SAND PAPER.
B) SOLVENT CLEAN WITH BMS 11-7
3 CLEAN SK2-5085-139-1 PER 4. BOND WITH KNIFE COAT OF EC 3532 (3M) STRUCTURAL ADHESIVE.
2 VELCRO PILE (THE HARTWELL CORP.) 2.00 INCH WIDE POLYESTER FASTENING TAPE. BOND TO SK2-5085-139-1 PER 3 TO MATCH VELCRO HOOK ON MLI INNER PANELS.
1 SEW THE OUTER DACRON NET LAYERS (2) OF ADJACENT PANELS TOGETHER USING DACRON THREAD
NAS3-15848
K.W. OSBORNE 11-28-72
D.L. BARCLAY 7-9-73
MLI - INSTALLATION, HALF SCALE LH2 TEST MODEL
81205 SK2-5085-141
2-5520

Figure D-13

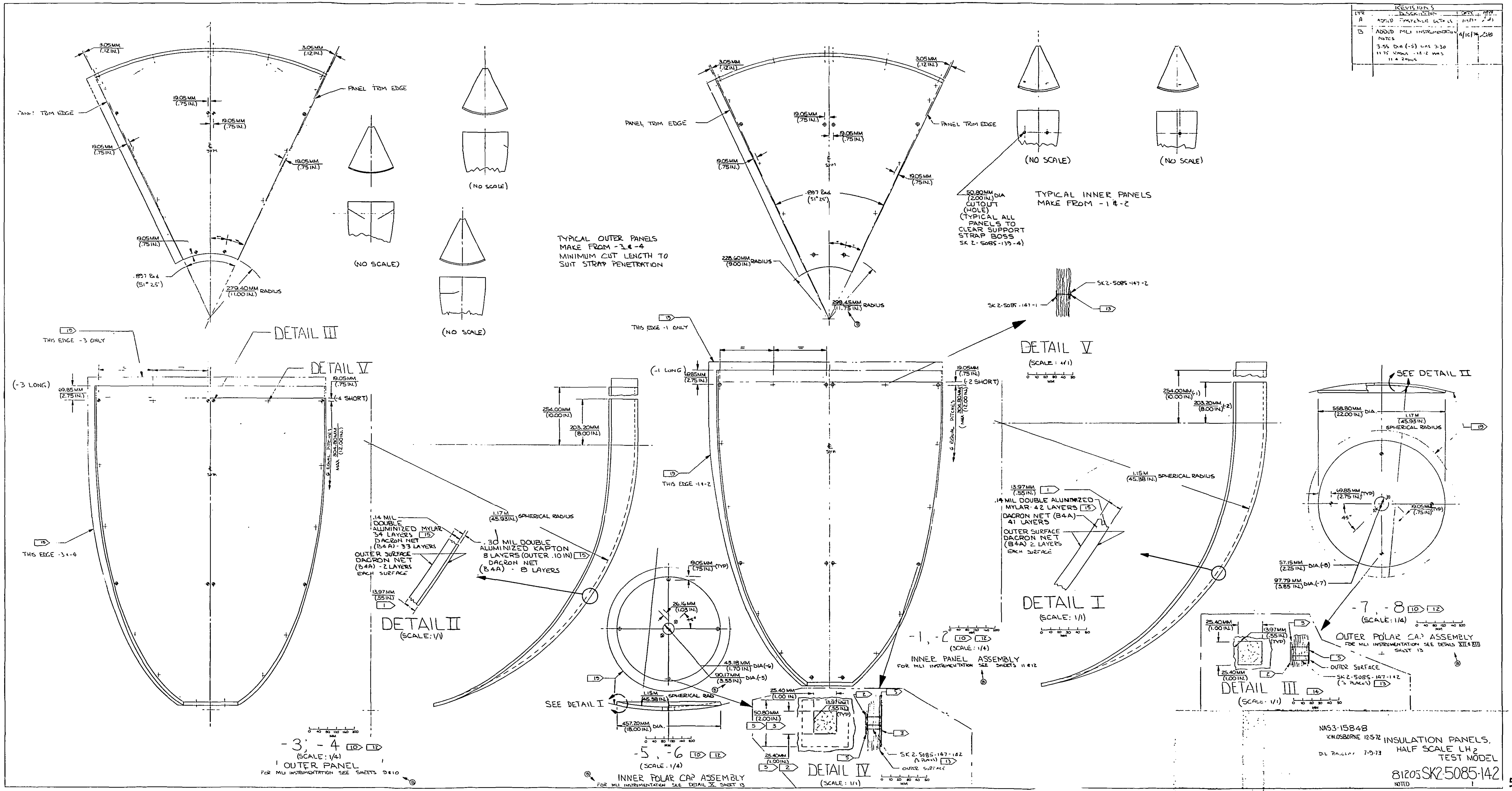

REVISIONS
A ADDED FASTENER DETAILS
B ADDED MLI INSTRUMENTATION NOTES
TYPICAL OUTER PANELS MAKE FROM -3 & -4 MINIMUM CUT LENGTH TO SUIT STRAP PENETRATION
TYPICAL INNER PANELS MAKE FROM -1 & -2
50.80MM (2.00IN.) DIA CUTOUT (HOLE) (TYPICAL ALL PANELS TO CLEAR SUPPORT STRAP BOSS SK 2-5085-139-4)
(NO SCALE)
PANEL TRIM EDGE
.897 Rad (51° 25')
279.40MM (11.00IN.) RADIUS
228.60MM (9.00IN.) RADIUS
298.45MM (11.75IN.) RADIUS
THIS EDGE -3 ONLY
THIS EDGE -1 ONLY
THIS EDGE -1 & -2
THIS EDGE -3 & -4
(-3 LONG)
(-4 SHORT)
(-1 LONG)
(-2 SHORT)
DETAIL III
DETAIL V
(SCALE: 1/1)
SK2-5085-147-1
SK2-5085-147-2
.14 MIL DOUBLE ALUMINIZED MYLAR 34 LAYERS
DACRON NET (B4A) - 33 LAYERS
OUTER SURFACE DACRON NET (B4A) - 2 LAYERS EACH SURFACE
.30 MIL DOUBLE ALUMINIZED KAPTON 8 LAYERS (OUTER .10 IN)
DACRON NET (B4A) - 8 LAYERS
1.17M (45.93IN.) SPHERICAL RADIUS
DETAIL II (SCALE: 1/1)
.14 MIL DOUBLE ALUMINIZED MYLAR 42 LAYERS
DACRON NET (B4A) 41 LAYERS
OUTER SURFACE DACRON NET (B4A) 2 LAYERS EACH SURFACE
1.15M (45.38IN.) SPHERICAL RADIUS
DETAIL I (SCALE: 1/1)
SEE DETAIL I
SEE DETAIL II
457.20MM (18.00IN.) DIA.
558.80MM (22.00IN.) DIA.
43.18MM (1.70IN.) DIA (-6)
90.17MM (3.55IN.) DIA (-5)
57.15MM (2.25IN.) DIA (-8)
97.79MM (3.85IN.) DIA (-7)
-3, -4 (SCALE: 1/4) OUTER PANEL
FOR MLI INSTRUMENTATION SEE SHEETS 9 & 10
-5, -6 (SCALE: 1/4) INNER POLAR CAP ASSEMBLY
FOR MLI INSTRUMENTATION SEE DETAIL X SHEET 13
-1, -2 (SCALE: 1/4) INNER PANEL ASSEMBLY
FOR MLI INSTRUMENTATION SEE SHEETS 11 & 12
-7, -8 (SCALE: 1/4) OUTER POLAR CAP ASSEMBLY
FOR MLI INSTRUMENTATION SEE DETAILS XII & XIII SHEET 13
DETAIL IV (SCALE: 1/1)
SK2-5085-147-1 & 2
OUTER SURFACE
NAS3-15848
K.W.OSBORNE 12-5-72
INSULATION PANELS, HALF SCALE LH2 TEST MODEL
81205 SK2-5085-142
2-5520

Figure D-14

[redacted]

LIST OF MATERIAL

REV LTR

				QTY REQD	PART OR IDENTIFYING NUMBER	NOMENCLATURE OR DESCRIPTION	MATERIAL AND SPECIFICATION
				1	-21	OUTER PANEL ASSEMBLY (SHORT)	9
				1	-20		
				1	-19		
				1	-18		
				1	-17		
				1	-16	OUTER PANEL ASSEMBLY (SHORT)	9
				1	-15	OUTER PANEL ASSEMBLY (LONG)	8
				1	-14		
				1	-13		
				1	-12		
				1	-11		
				1	-10		
				1	-9	OUTER PANEL ASSEMBLY (LONG)	8
				1	-8	OUTER MLI POLAR CAP ASSEMBLY	1
				1	-7	OUTER MLI POLAR CAP ASSEMBLY	1
				1	-6	INNER MLI POLAR CAP ASSEMBLY	1
				1	-5	INNER MLI POLAR CAP ASSEMBLY	1
					-4	OUTER MLI PANEL ASSEMBLY (SHORT)	1
					-3	OUTER MLI PANEL ASSEMBLY (LONG)	1
					-2	INNER MLI PANEL ASSEMBLY (SHORT)	1
					-1	INNER MLI PANEL ASSEMBLY (LONG)	1
				QTY REQD	PART OR IDENTIFYING NUMBER	NOMENCLATURE OR DESCRIPTION	MATERIAL AND SPECIFICATION

[redacted] LIST OF MATERIAL

FIGURE D-15	SIZE A	CODE IDENT NO. 81205	SK2-5085-142
	SCALE		SHEET 2

[redacted]

REV LTR A

LIST OF MATERIAL

	QTY REQD	PART OR IDENTIFYING NUMBER	NOMENCLATURE OR DESCRIPTION	MATERIAL AND SPECIFICATION
A	1	-42	SIMULATED PLMB WRAP SUPPORT	
A	1	-41	SIMULATED PLMB WRAP ASSY. (LONG)	
A	1	-40	SIMULATED PLMB WRAP ASSY. (SHORT)	
A	1	-39	INLET TUBE WRAP SUPPORT	
A	1	-38	INLET TUBE WRAP ASSEMBLY (LONG)	
A	1	-37	INLET TUBE WRAP ASSEMBLY (SHORT)	
	1	-36	INNER PANEL ASSEMBLY (LONG)	6
	1	-35		
	1	-34		
	1	-33		
	1	-32		
	1	-31		
	1	-30	INNER PANEL ASSEMBLY (LONG)	6
	1	-29	INNER PANEL ASSEMBLY (SHORT)	7
	1	-28		
	1	-27		
	1	-26		
	1	-25		
	1	-24		
	1	-23	INNER PANEL ASSEMBLY (SHORT)	7
	1	-22	OUTER PANEL ASSEMBLY (SHORT)	9

QTY REQD	PART OR IDENTIFYING NUMBER	NOMENCLATURE OR DESCRIPTION	MATERIAL AND SPECIFICATION

[redacted]

LIST OF MATERIAL

FIGURE D-16

SIZE	CODE IDENT NO.	
A	81205	SK2-5085-142
SCALE		SHEET 3

[redacted]

LIST OF MATERIAL

REV LTR

				QTY REQD	PART OR IDENTIFYING NUMBER	NOMENCLATURE OR DESCRIPTION	MATERIAL AND SPECIFICATION
				1192	SK2-5085-147-2	BUTTON	
				1192	SK 2-5085-147-1	BUTTON-STUD	

QTY REQD	PART OR IDENTIFYING NUMBER	NOMENCLATURE OR DESCRIPTION	MATERIAL AND SPECIFICATION

[redacted]

LIST OF MATERIAL

	SIZE	CODE IDENT NO.	
FIGURE D-17	A	81205	SK2-5085-142
	SCALE		SHEET 4

D1 4316 3085 ORIG. 1/71

REV LTR

1. BLANKET DENSITY = 75 LAYERS/INCH. ONE LAYER EQUALS ONE .14 MIL DOUBLE ALUMINIZED MYLAR SHIELD (OR ONE .30 MIL DOUBLE ALUMINIZED KAPTON, WHICHEVER IS SPECIFIED) PLUS ONE DACRON NET (B4A) SPACER.
   NUMBER OF SHIELDS = 42
   NUMBER OF SPACERS = 41
   OUTER PANEL SURFACES CONSIST OF 2 DACRON NET (B4A) LAYERS
2. VELCRO HOOK #100 (THE HARTWELL CORP) 1.00 INCH WIDE POLYESTER FASTENING TAPE 11
3. VELCRO PILE (THE HARTWELL CORP.) 2.00 INCH WIDE POLYESTER FASTENING TAPE 11
4. EE-6600 (PERMACEL) REFLECTIVE, POLYESTER, INTERLINED, PRESSURE SENSITIVE TAPE.

FIGURE D-18

SIZE	CODE IDENT NO.	
A	81205	SK2-5035-142
SCALE		SHEET 5

REV LTR

5 7402 (BORDON, MYSTIK) ALUMINUM FOIL, SILICONE ADHESIVE, PRESSURE SENSITIVE TAPE. POSITION TWO FOIL LAYERS TO SANDWICH THE TWO OUTER DACRON NET LAYERS AND THE NYLON PIN BUTTONS BETWEEN THE ADHESIVE BACKED FOIL SURFACES.

6 MAKE FROM -1

7 MAKE FROM -2

8 MAKE FROM -3

9 MAKE FROM -4

10 ALL HOLES, EDGES, AND SLITS CUT NORMAL TO PANEL CURVATURE

11 BOND WITH KNIFE COAT OF EC 3532 (3M) STRUCTURAL ADHESIVE

12 FASTENER AND THERMOCOUPLE DIMENSIONS MEASURED ALONG PANEL CURVATURE

FIGURE D-19

SIZE	CODE IDENT NO.	
A	81205	SK2-5085-142
SCALE		SHEET 6

REV LTR

13 HEAT FORM RETENTION BALL

14 LOCATIONS TO MATCH DETAIL IV LOCATIONS ON INNER PANELS

15 FORM SHIELD TO CONTOUR BY DRAPING OVER LAYUP TOOL THEN FOLDING THE WRINKLES ALONG THE EDGES FLAT. TAPE FOLDS IN PLACE WITH 4, 1.00 x .15 IN. ARRANGE FOLDS TO AVOID A LOCAL THICKNESS BUILDUP IN THE BLANKET.

16 TAPE THERMOCOUPLES IN PLACE WITH 4, 1.00 x .15 IN.

17 E-36-2-507-001 #36 CHROMEL -CONSTANTAN THERMOCOUPLE WIRE, TEFLON INSULATED.

18 RADIATION SHIELDS ARE NUMBERED STARTING FROM THE INNER LAYER OF EACH PANEL.

19 EXTEND OUTER SURFACE DACRON NET (B4A), 2 LAYERS, 1.50 IN. BEYOND TRIM EDGE OF PANEL AT EDGE SHOWN.

FIGURE D-20

SIZE	CODE IDENT NO.	
A	81205	SK2-5085-142
SCALE		SHEET 7

D1 4310-2001 ORIG 3/71

REV LTR A

ASSEMBLY PROCEDURES

1. WHITE NYLON GLOVES OR EQUIVALENT SHALL BE USED IN HANDLING ALL MATERIAL TO INSURE CLEANLINESS. ALL MATERIALS SHALL BE FREE OF DIRT, GREASE, OR OTHER CONTAMINATION MATERIAL.

2. LAY UP ALTERNATE LAYERS OF RADIATION SHIELDS AND DACRON NET PER 1. CONTOUR SHIELDS PER 15.

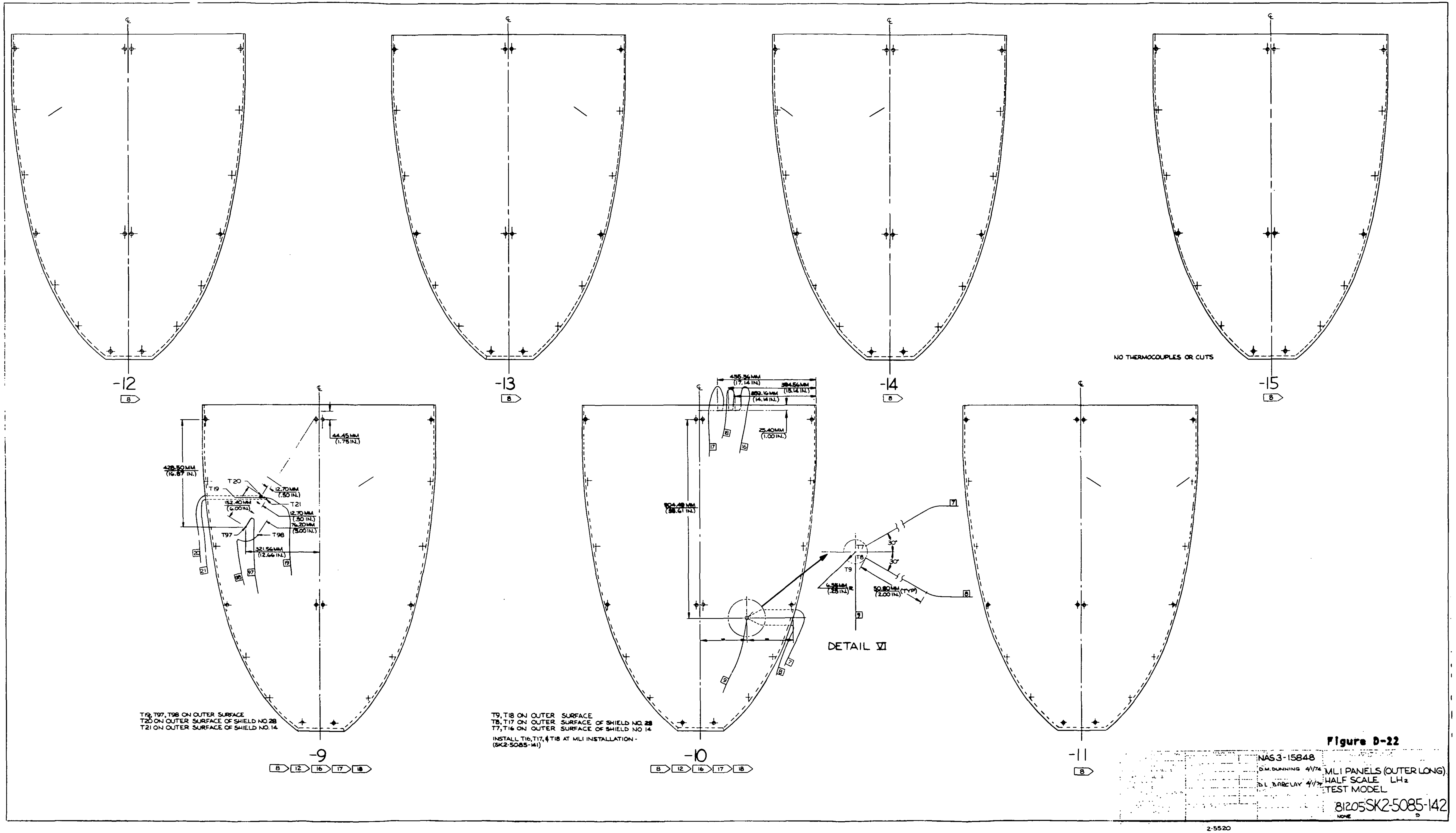
3. WHEN SPECIFIED, INSTALL THERMOCOUPLES 17 DURING INSULATION LAY-UP. TAPE THERMOCOUPLES IN PLACE PER 16

4. WHITE NYLON COATS OR EQUIVALENT SHALL BE WORN DURING FABRICATION AND INSTALLATION OF MLI PANEL ASSEMBLIES TO INSURE INSULATION CLEANLINESS.

A

FIGURE D-21

SIZE	CODE IDENT NO.	SK2-5085-142
A	81205	
SCALE		SHEET 9



-12
-13
-14
-15
NO THERMOCOUPLES OR CUTS
-9
-10
-11
DETAIL VI
428.50 MM (16.87 IN.)
44.45 MM (1.75 IN.)
12.70 MM (.50 IN.)
152.40 MM (6.00 IN.)
12.70 MM (.50 IN.)
76.20 MM (3.00 IN.)
321.56 MM (12.66 IN.)
435.36 MM (17.14 IN.)
384.56 MM (15.14 IN.)
359.16 MM (14.14 IN.)
25.40 MM (1.00 IN.)
904.49 MM (35.61 IN.)
50.80 MM (2.00 IN.) (TYP)
T19, T97, T98 ON OUTER SURFACE
T20 ON OUTER SURFACE OF SHIELD NO. 28
T21 ON OUTER SURFACE OF SHIELD NO. 14
T9, T18 ON OUTER SURFACE
T8, T17 ON OUTER SURFACE OF SHIELD NO. 28
T7, T16 ON OUTER SURFACE OF SHIELD NO 14
INSTALL T16, T17, & T18 AT MLI INSTALLATION - (SK2-5085-141)
NAS3-15848
D.M. DUNNING 4/1/74
D.L. BARCLAY 4/1/74
MLI PANELS (OUTER LONG) HALF SCALE LH2 TEST MODEL
81205 SK2-5085-142
NONE
2-5520

Figure D-22

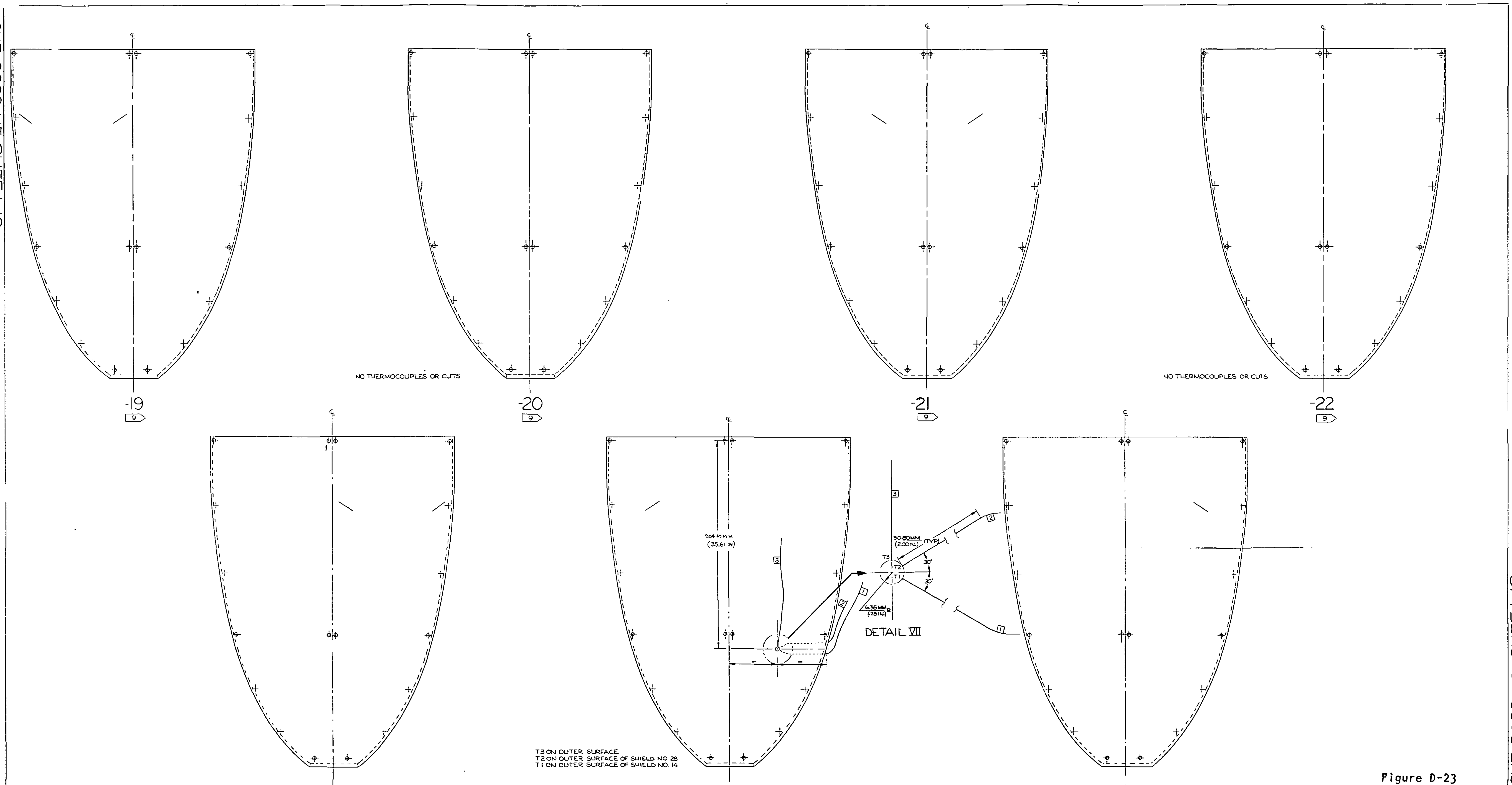
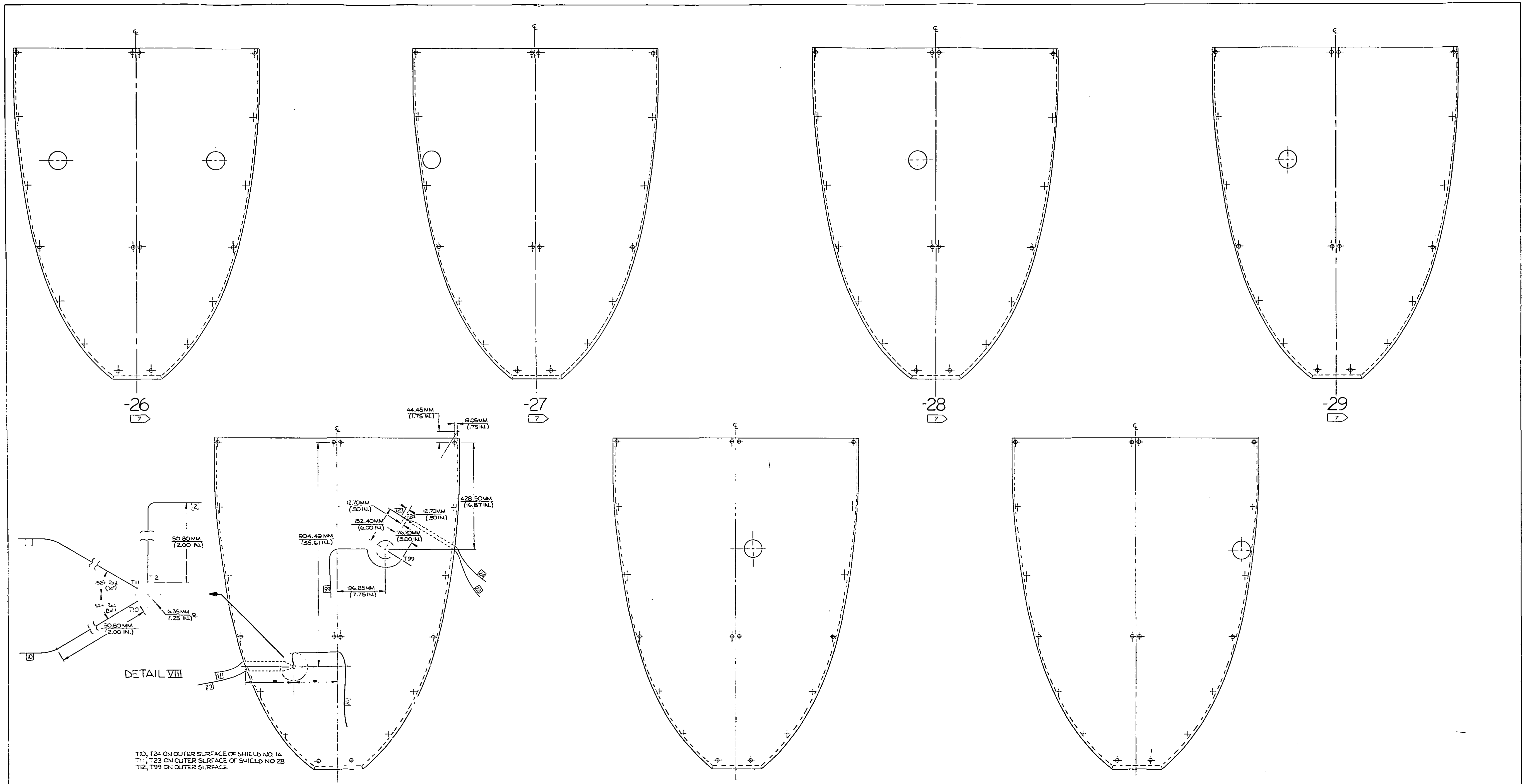


Figure D-23

NAS 3-15848
D.M. DUNNING 4/1/74
D.L. BARCLAY 4/1/77
MLI PANELS (OUTER SHORT) HALF SCALE LH_2 TEST MODEL
81205 SK2-5085-142
NONE 10
2-5520



NAS3-15848 **Figure D-24**

D.M. DUNNING 4/1/74

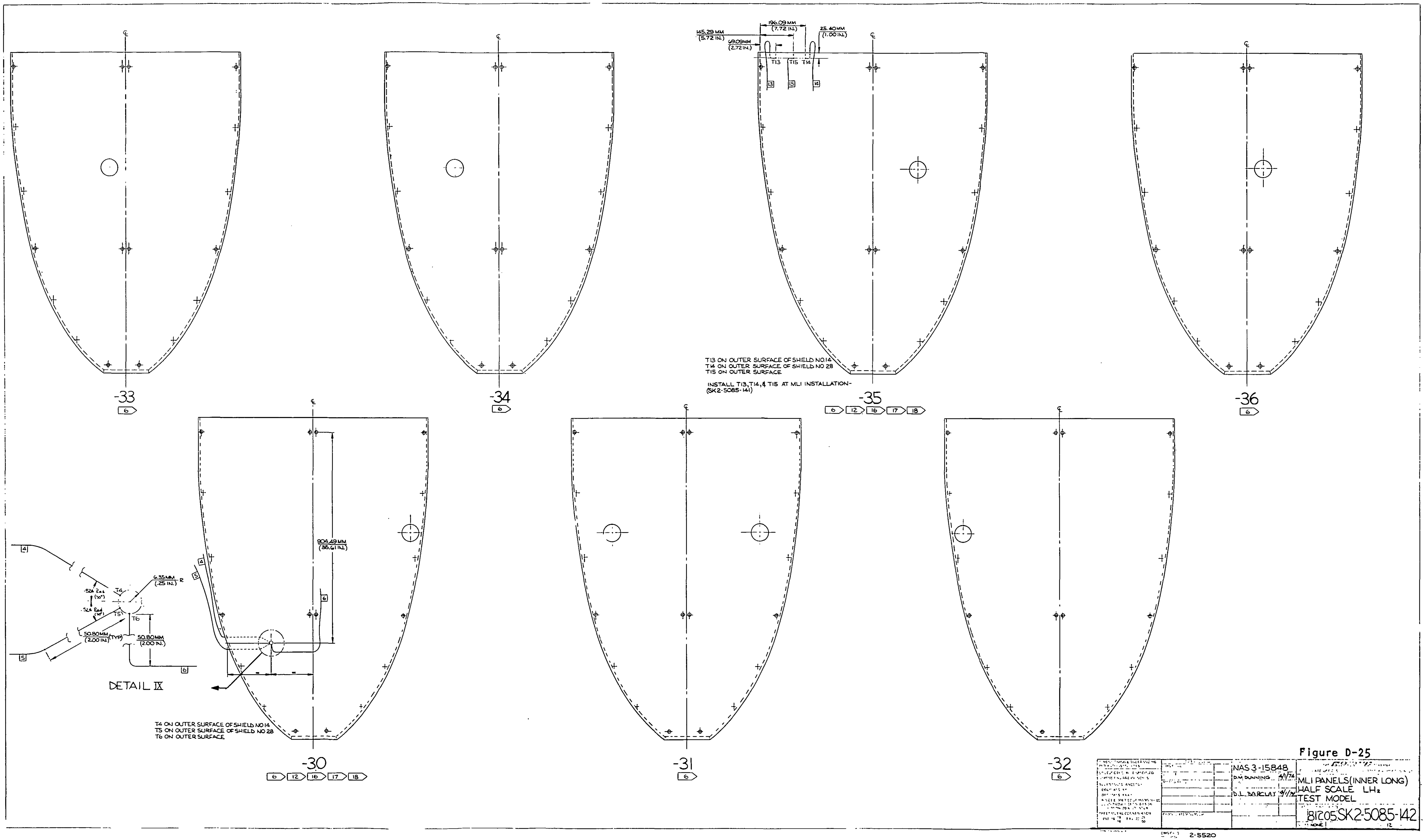
D L BARCLAY 4/1/74

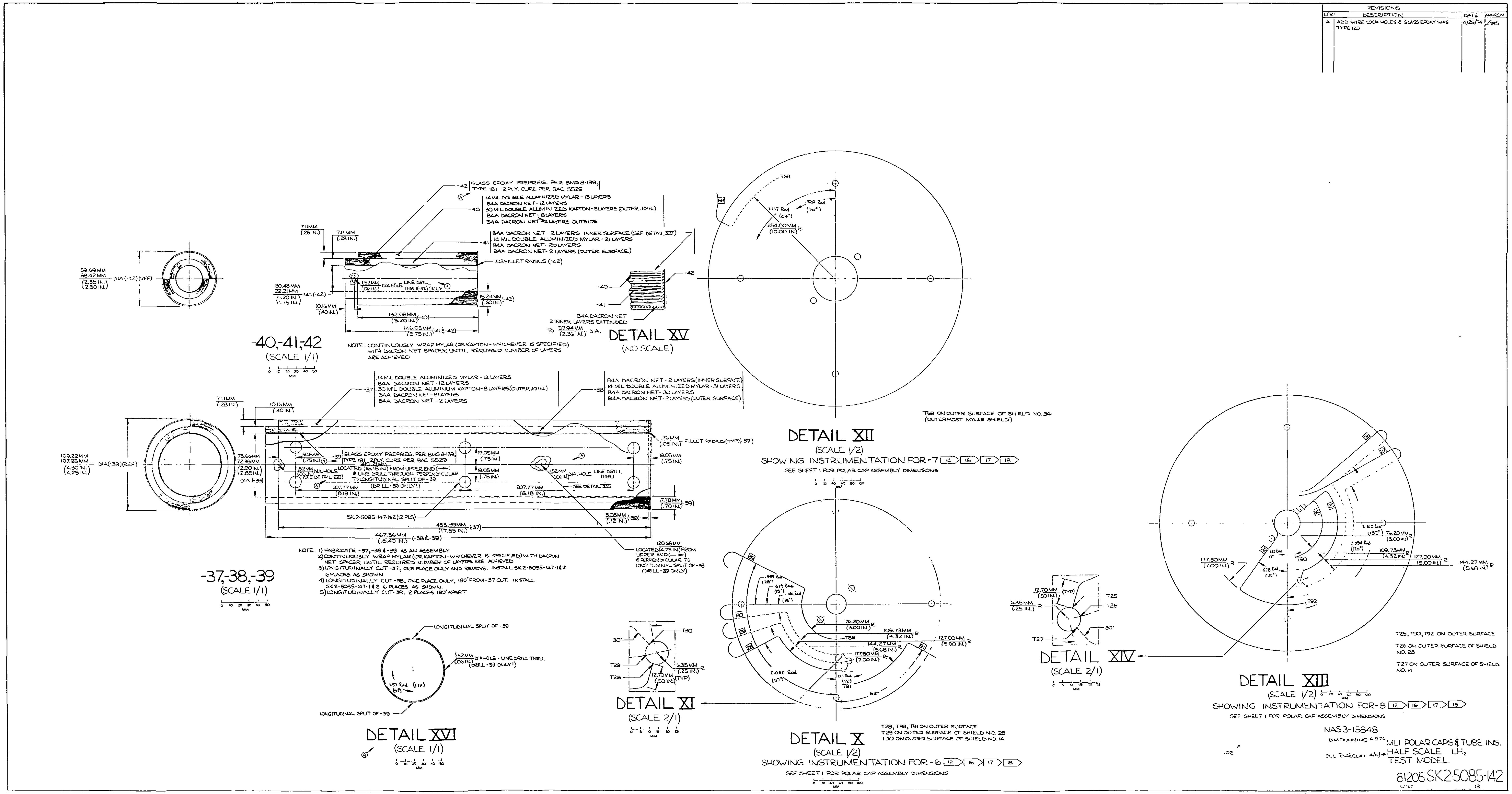
MLI PANELS (INNER SHORT) HALF SCALE LH_2 TEST MODEL

81205 SK2-5085-142

NONE

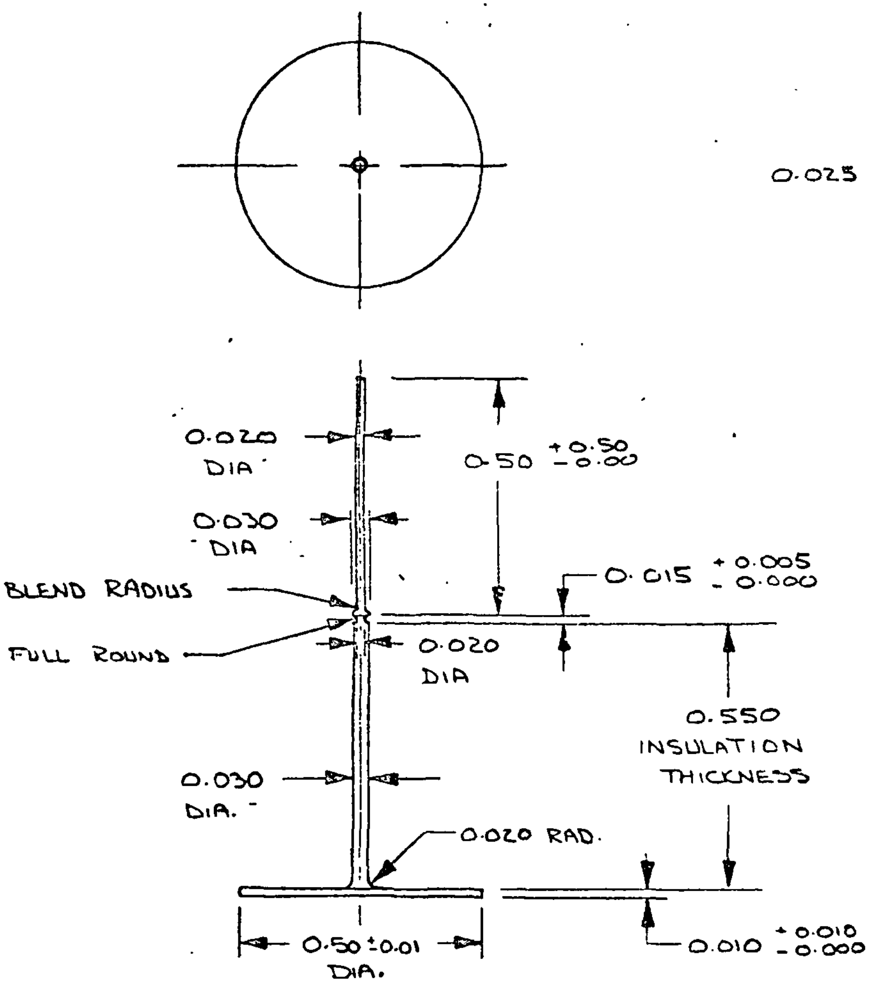
2-5520


145.29 MM (5.72 IN.)
196.09 MM (7.72 IN.)
25.40 MM (1.00 IN.)
69.09 MM (2.72 IN.)
T13 T15 T14
13 15 14
T13 ON OUTER SURFACE OF SHIELD NO.14
T14 ON OUTER SURFACE OF SHIELD NO 28
T15 ON OUTER SURFACE
INSTALL T13, T14, & T15 AT MLI INSTALLATION-
(SK2-5085-141)
-33
-34
-35
-36
-30
-31
-32
904.49 MM (35.61 IN.)
6.35 MM (.25 IN.) R
T4
T5
T6
50.80 MM (2.00 IN.) (TYP)
50.80 MM (2.00 IN.)
DETAIL IX
T4 ON OUTER SURFACE OF SHIELD NO 14
T5 ON OUTER SURFACE OF SHIELD NO 28
T6 ON OUTER SURFACE
NAS 3-15848
D.M. DUNNING 4/1/74
D.L. BARCLAY 4/1/74
MLI PANELS (INNER LONG)
HALF SCALE LH2
TEST MODEL
81205 SK2-5085-142
NONE
12
2-5520
Figure D-25

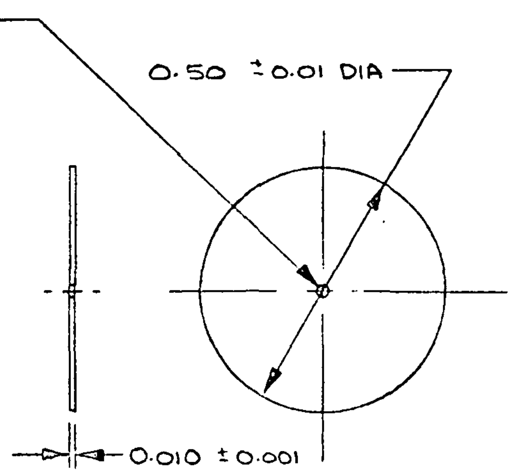


2-5520

Figure D-26



– 1
BUTTON – PIN STUD
MAT'L: ZYTEL 103HSI-L NYLON RESIN
TOLERANCE ON X.XXX IS ± 0.002
(SCALE 4/1)



– 2
BUTTON
MAT'L: ZYTEL 103HSI-L NYLON RESIN
(SCALE 4/1)

FIGURE D-27
SK 2-5085-147 — MLI FASTENERS

SK2080-1491

NOTES

1. SPECIFICATIONS AND STANDARDS FOR THE CONTROL OF MANUFACTURING OPERATIONS (AS APPLICABLE):
   - SURFACE ROUGHNESS SYMBOLS PER BACD [illegible]
   - WELDING AND BRAZING SYMBOLS PER BACD [illegible]
   - FORM, STRAIGHTEN & FIT METAL PARTS PER BAC [illegible]
   - MATERIAL SUBSTITUTIONS & EQUIVALENTS PER BAC [illegible]
   - PART MARKING PER BAC [illegible]
   - BOLT & NUT INSTALLATION PER BAC [illegible]
   - FINISH CODES PER DOCUMENT D2-[illegible]
   - RIVET INSTALLATION & SYMBOLS PER BAC [illegible]

REV STATUS	
SH	LTR

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED

7 CORE MAY BE SPLICED. WIRE CORE SEAMS TOGETHER WITH .13 CM (.051 IN) DIA. CRES WIRE AND POT PER 6.

6 POT WITH STRUCTURAL FOAMING ADHESIVE PER BAC 5-90, TYPE 2, CLASS 350, GRADE 50.

5 CLEAN PER HYSOL BULLETIN A9-123. BOND WITH EA 934 (HYSOL DIVISION THE DEXTER CORP.) WITH VACUUM BAG PRESSURE PER HYSOL BULLETIN A5-134.

4 6061-T6 ALUM BAR PER QQ-A-225/8

3 6061-T6 ALUM SHEET PER QQ-A-250/11

2 CLEAN, PRIME WITH METLBOND 329 TYPE 2, APPLY METLBOND 329 ADHESIVE (NARMCO MATERIALS DIV. WHITTAKER CORP). CURE BOND AT 408°K (275°F) FOR 90 MINUTES AT 101.4 kN/m² (14.7 PSI) VACUUM PRESSURE.

1 FLEX CORE 3/16-5056/F80-.0014 68.8 kg/m³ (4.3 lb/FT³) ALUM HONEY COMB, HEXCEL PRODUCTS INC.

QTY REQD -2	QTY REQD -1	PART OR IDENTIFYING NUMBER	NOMENCLATURE OR DESCRIPTION	ZONE	MATERIAL AND SPECIFICATION
	24	NAS1226C18	BOLT		
	80	NAS1226C15	BOLT		
	32	NAS1224C18	BOLT		
	104	NAS960C616L	WASHER		
	32	NAS960416L	WASHER		
	104	NAS679C6M	NUT		
	32	NAS679C4M	NUT		
	4	-13	RING SEGMENT-OUTER	B6-2	.50 × 1.0 × 81.62 ALUM BAR 4 5
	4	-12	RING SEGMENT-INNER	B4-2	.50 × 1.0 × 79.02 ALUM BAR 4 5
	4	-11	SPLICE PLATE-OUTER	B6-2	.100 × 2.10 × 3.60 ALUM SHEET 3
	4	-10	SPLICE PLATE-INNER	B6-2	.100 × 2.10 × 3.60 ALUM SHEET 3
	4	-9	ATTACHMENT R-OUTER	C3-2	.080 × 2.65 × 80.21 ALUM SHEET 3
	4	-8	ATTACHMENT R-INNER	C3-2	.080 × 2.65 × 79.02 ALUM SHEET 3
	4	-7	DOUBLER R-OUTER	C3-2	.100 × 2.65 × 17.85 ALUM SHEET 3
	4	-6	DOUBLER R-INNER	C3-2	.100 × 2.65 × 17.59 ALUM SHEET 3
1	-	-5	SKIN-INNER	B3-2	.080 × 6.00 × 80.20 ALUM SHEET 3
1	-	-4	SKIN-OUTER	B3-2	.080 × 6.00 × 79.10 ALUM SHEET 3
1	-	-3	CORE	B3-2	1 7 .605 × 6.00 × 80.20 FLEX CORE
-	4	-2	TRANSITION SEGMENT ASSEMBLY		2
-	-	-1	TRANSITION ASSEMBLY		

PARTS LIST

PART NUMBER	NEXT ASSY	USED ON	EFFECTIVITY	DWG BY NUMBER	REV LTR
APPLICATION					

FASTENER CODES

DIMENSIONING & TOLERANCING PER ANSI (USASI) Y14.5
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES: ANGLES ± 1°
DECIMALS .XX ± .02
DECIMALS .XXX ± .005
RIVET & BOLT EDGE MARGINS ± .05
BEND RADII ± .01 ON .03 & .06
± .03 ON .09 & GREATER
SHEET METAL CORNER RADII INT .16 EXT .22

DATA REVIEW: DWG QUAL / STRUCT / MATL & PRCS

CHANGE/ITEM NUMBER

CONTRACT NUMBER NAS3-15848

DRN K.W. OSBORNE 4-3-73

CHK

ENGR [illegible] 4-16-73

ORG

PROJECT APPROVAL

THE BOEING COMPANY
CORPORATE OFFICES SEATTLE, WASHINGTON

TRANSITION ASSEMBLY
F/S TEST-
HALF SCALE LH_2 TEST MODEL

SIZE J CODE IDENT NO 81205 SK2-5085-149

SCALE NONE SH 1 OF 2

DWG ORIG BY (ORG) 2-5520

Figure D-28

SK2-5085-149

2KS2080-1491

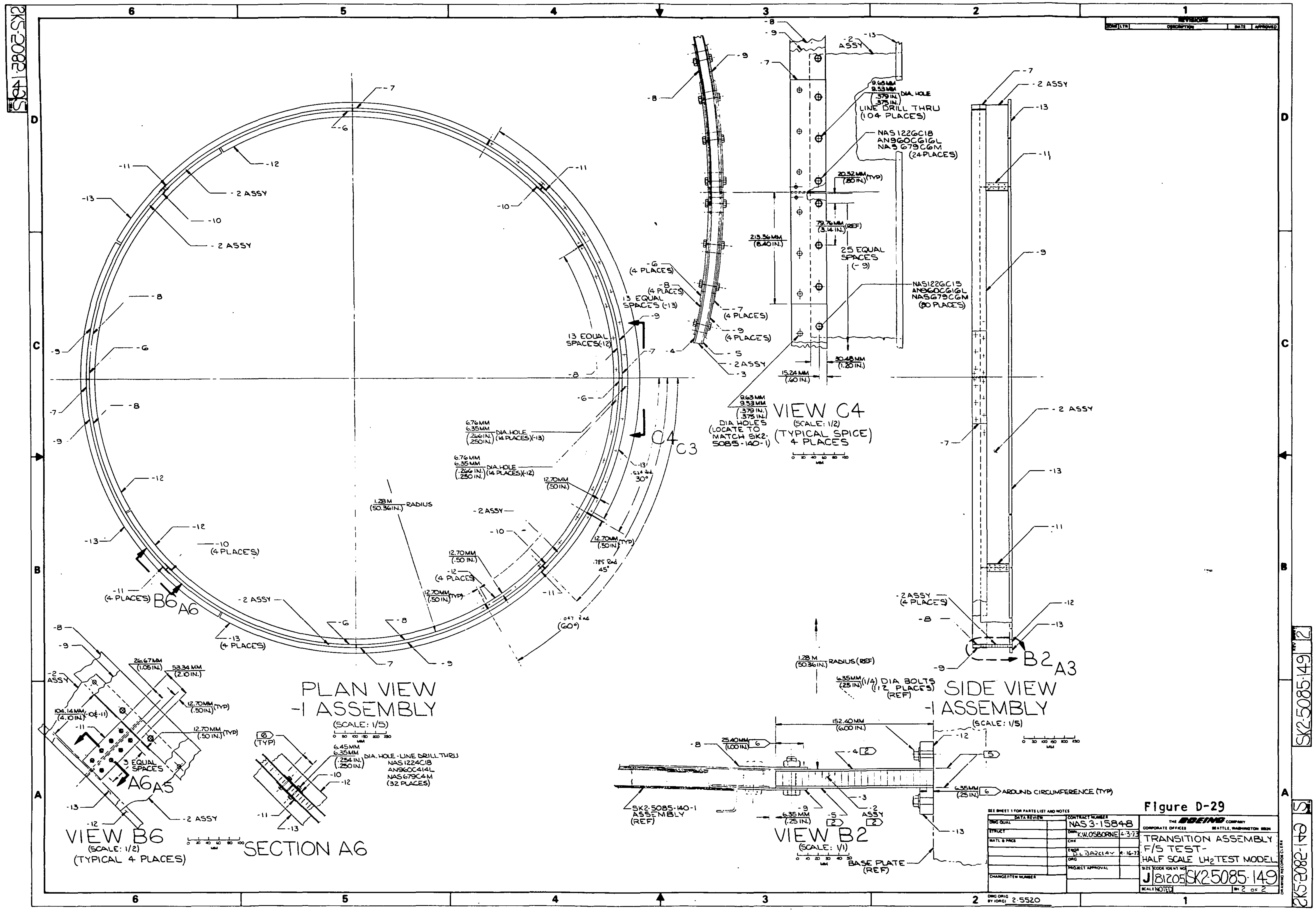
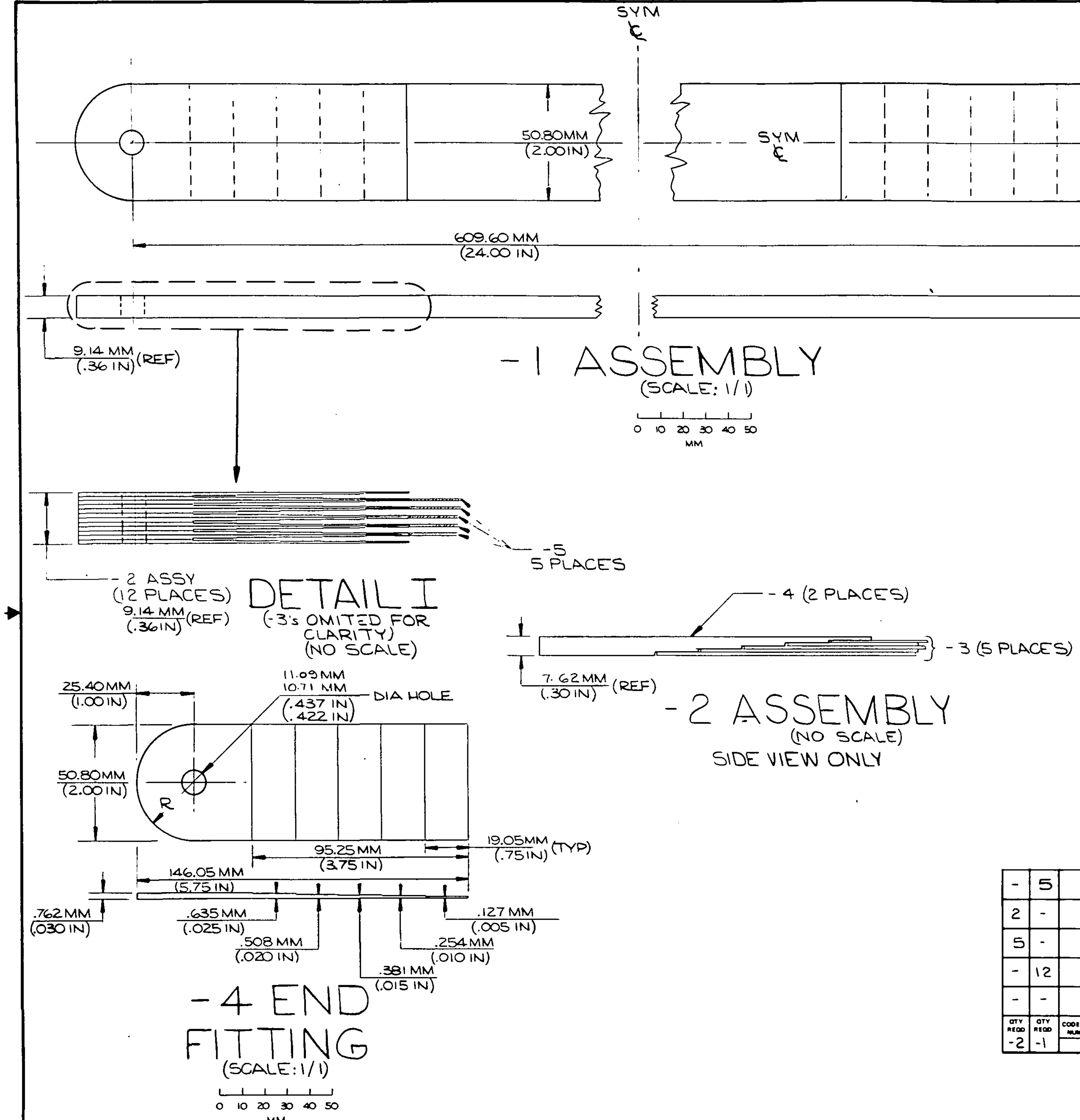

PLAN VIEW
-1 ASSEMBLY
(SCALE: 1/5)
1.28 M (50.36 IN.) RADIUS
13 EQUAL SPACES (-13)
13 EQUAL SPACES (-12)
VIEW C4
(SCALE: 1/2)
(TYPICAL SPICE)
4 PLACES
LINE DRILL THRU (104 PLACES)
NAS1226C18
AN960C616L
NAS679C6M
(24 PLACES)
25 EQUAL SPACES (-9)
NAS1226C15
AN960C616L
NAS679C6M
(80 PLACES)
DIA. HOLES (LOCATE TO MATCH SK2-5085-140-1)
SIDE VIEW
-1 ASSEMBLY
(SCALE: 1/5)
1.28 M (50.36 IN.) RADIUS (REF)
6.35 MM (.25 IN.) (1/4) DIA BOLTS (12 PLACES) (REF)
VIEW B6
(SCALE: 1/2)
(TYPICAL 4 PLACES)
3 EQUAL SPACES
SECTION A6
NAS1224C8
AN960C414L
NAS679C4M
(32 PLACES)
DIA. HOLE - LINE DRILL THRU
VIEW B2
(SCALE: 1/1)
SK2-5085-140-1 ASSEMBLY (REF)
AROUND CIRCUMFERENCE (TYP)
BASE PLATE (REF)
CONTRACT NUMBER NAS 3-15848
K.W. OSBORNE 4-3-73
THE BOEING COMPANY
CORPORATE OFFICES SEATTLE, WASHINGTON
TRANSITION ASSEMBLY
F/S TEST-
HALF SCALE LH_2 TEST MODEL
J 81205 SK2-5085-149
SCALE NOTED SH 2 OF 2
2-5520

Figure D-29



NOTES

1. SPECIFICATIONS AND STANDARDS FOR THE CONTROL OF MANUFACTURING OPERATIONS (AS APPLICABLE):
   SURFACE ROUGHNESS SYMBOLS PER BACD 2007
   WELDING AND BRAZING SYMBOLS PER BACD 2022
   FORM, STRAIGHTEN & FIT METAL PARTS PER BAC 5300
   MATERIAL SUBSTITUTIONS & EQUIVALENTS PER BAC 5008
   PART MARKING PER BAC 5307
   BOLT & NUT INSTALLATION PER BAC 5009
   FINISH CODES PER DOCUMENT D2-5000
   RIVET INSTALLATION & SYMBOLS PER BAC 5004

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED

1. CUT FROM 50.80MM (2.0 IN) WIDE PREPREG 2 PRD 49-3 3 TAPE
2. RESIN SYSTEM ERLA 4617 (UNION CARBIDE CORP.) WITH PHENYLENEDIAMINE (CL) CATALYST (ALLIED CHEMICALS)
3. PRD-3 SINGLE END YARN - 380 DENIER - 400 FILAMENTS PER YARN - CONTINUOUS - PRODUCERS TWIST - NO FINISH (E.I. DUPONT)
4. 6AL-4V TITANIUM SHEET PER MIL-T-9046E, TYPE III, COMP C.
5. FIBERGLASS EPOXY PREPREG PER BMS 8-139, TYPE 120, 2 PLY.
6. CURE WITH VACUUM BAG PRESSURE TWO HOURS AT 339°K (150°F) & FOUR HOURS AT 422°K (300°F)
7. CLEAN FAYING SURFACES OF -4 END FITTINGS PER HYSOL BULLETIN AS-123 & BOND WITH EA 934 (HYSOL DIVISION THE DEXTER CORP) WITH VACUUM BAG PRESSURE PER HYSOL BULLETIN AS-134.
8. CHEMICAL MILL PER BAC 5842.

QTY REQD -2	QTY REQD -1	CODE IDENT NUMBER	PART OR IDENTIFYING NUMBER	NOMENCLATURE OR DESCRIPTION	MATERIAL AND SPECIFICATION	MT TR	FINISH	PT MK	SERIALIZATION BASE NUMBER	REV LTR
-	5		-5	FILLER	50.80 MM WIDE 5					
2	-		-4	END FITTING	.76x 50.80 x 146.08 MM 4 8					
5	-		-3	TAPE	50.80 MM WIDE 1					
-	12		-2	LAMINATE ASSEMBLY	6					
-	-		-1	SUPPORT STRAP ASSEMBLY	7					

PARTS LIST

PART NUMBER	NEXT ASSY	USED ON	EFFECTIVITY	REV LTR

APPLICATION

FASTENER CODES

DIMENSIONING & TOLERANCING PER ANSI (USASI) Y 14.5

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES: ANGLES ± 1°
DECIMALS .XX ± .02
DECIMALS .XXX ± .001
RIVET & BOLT EDGE MARG ± .05
BEND RADII ± .01 ON .03 & .06
± .03 ON .09 & GREATER
SHEET METAL CORNER RADII
INT .16 $^{+.10}_{-.16}$ EXT .22 $^{+.38}_{-.00}$

DATA REVIEW: DWG QUAL / STRUCT / MATL & PRCS / CHANGE/ITEM NUMBER

CONTRACT NUMBER NAS3-15848

DRN K.W. OSBORNE 4-4-3

CHK

ENGR D.L. BARCLAY 4-11-3

ORG

PROJECT APPROVAL

THE BOEING COMPANY
CORPORATE OFFICES SEATTLE, WASHINGTON 98124

SUPPORT STRAP ASSEMBLY, OMS FUEL TANK

SIZE D CODE IDENT NO. 81205 SK2-5085-133

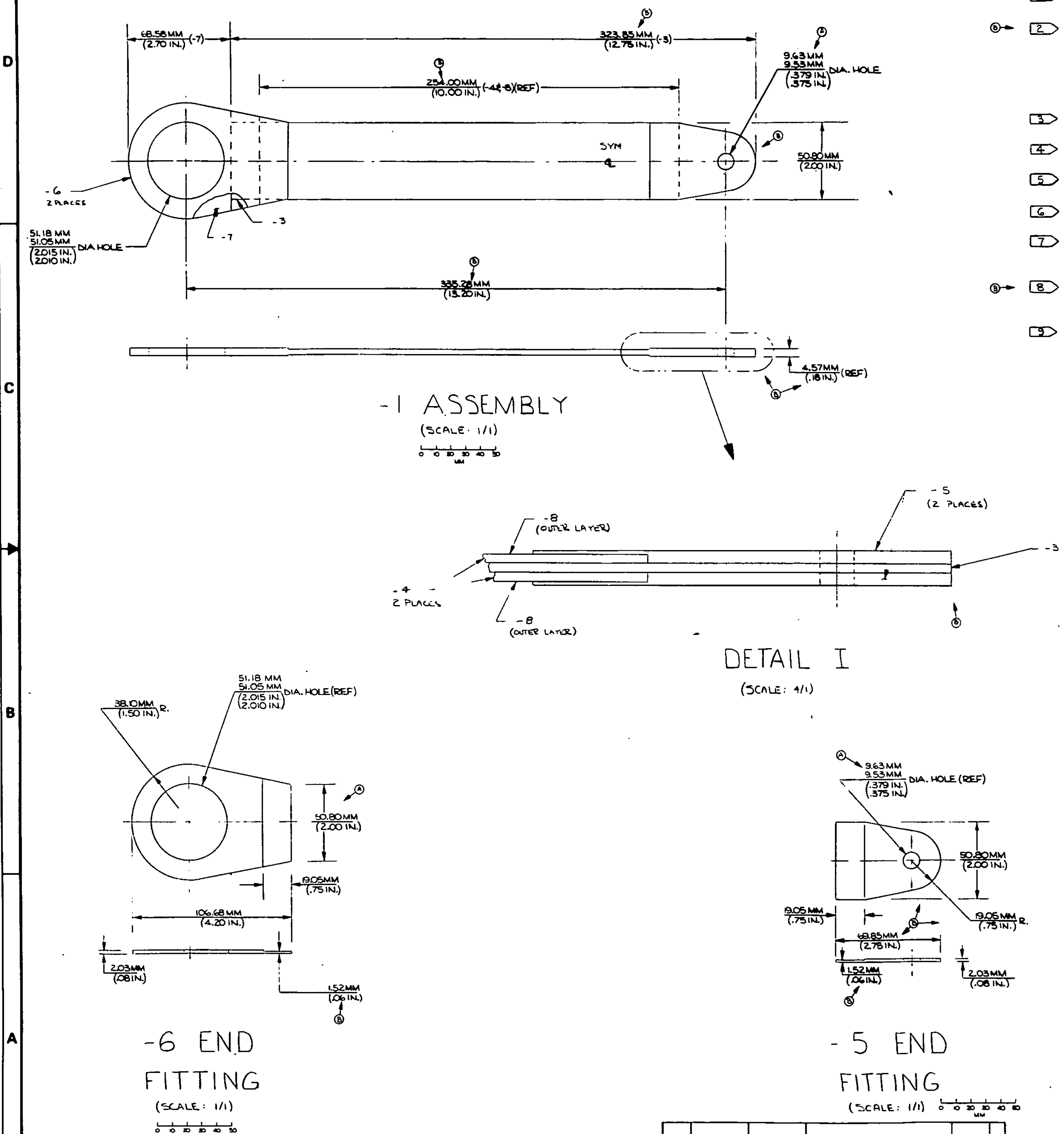
SCALE NOTED

DWG ORIG BY (ORG) 2-5520

SK2-5085-133

D0 6000 1225

Figure D-30



NOTES

1. SPECIFICATIONS AND STANDARDS FOR THE CONTROL OF MANUFACTURING OPERATIONS (AS APPLICABLE):
   - SURFACE ROUGHNESS SYMBOLS PER BACD 2007
   - WELDING AND BRAZING SYMBOLS PER BACD 2022
   - FORM, STRAIGHTEN & FIT METAL PARTS PER BAC 5300
   - MATERIAL SUBSTITUTIONS & EQUIVALENTS PER BAC 5000
   - PART MARKING PER BAC 5307
   - BOLT & NUT INSTALLATION PER BAC 5009
   - FINISH CODES PER DOCUMENT D3-8000
   - RIVET INSTALLATION & SYMBOLS PER BAC 5004

[1] 6AL-4V TITANIUM SHEET PER MIL-T-9046 E TYPE III COMPOSITION C CONDITION I (ANNEALED)

(B) [2] UNIDIRECTIONAL PRD 49-3/EPOXY COMPOSITE STRAP. FILAMENT WIND USING PRD 49-3 (E.I. DUPONT) - SINGLE END YARN - 180 DENIER - 480 FILAMENTS PER YARN - CONTINUOUS - PRODUCER'S TWIST - NO FINISH - 10 PLY. RESIN SYSTEM SHALL BE ERLA 4617 (UNION CARBIDE CORP) WITH m - PHENYLENEDIAMINE (CL) CATALYST (ALLIED CHEMICAL). COMPOSITE SHALL HAVE A FIBER CONTENT OF 60 ± 5% BY VOLUME.

[3] CURE WITH VACUUM BAG PRESSURE, TWO HOURS AT 339°K (150°F), TWO HOURS AT 422°K (300°F) AND ONE HOUR AT 450°K (350°F)

[4] CHEM-MILL PER BAC 5842

[5] CLEAN TITANIUM FAYING SURFACES WITH AN ALUMINA BLAST FOLLOWED BY A SILANE RINSE (UNION CARBIDE A1100)

[6] PRIOR TO BONDING, LIGHTLY SAND -2 TAPE ASSEMBLY & -7 FILLER LOCALLY AT INTERFACE WITH -5 & -6 END FITTING

[7] CLEAN PER HYSOL BULLETIN G1-600, BOND WITH EA 934 (HYSOL DIVISION THE DEXTER CORP.) WITH VACUUM BAG PRESSURE PER HYSOL BULLETIN AS-134. CURE 1 HR AT 367°K (200°F)

(B) [8] FIBERGLASS/EPOXY COMPOSITE FILLER. FIBERGLASS CLOTH, TYPE 120, 4 PLY. RESIN SYSTEM SHALL BE ERLA 4617 (UNION CARBIDE CORP.) WITH m - PHENYLENEDIAMINE (CL) CATALYST (ALLIED CHEMICAL).

[9] FIBERGLASS/EPOXY COMPOSITE BINDER. FIBERGLASS CLOTH, TYPE 120, 1 PLY. RESIN SYSTEM PER [2].

REVISIONS

ZONE	LTR	DESCRIPTION	DATE	APPROVED
	A	ALTERED TOLERANCES AND DIA OF -5 END FTG HOLE ADDED -6 END FTG DIM	7/13/73	
	B	ALTERED [2], [8], -1, -5 & -6	10/2/73	

PARTS LIST

QTY REQD	QTY REQD	QTY REQD	QTY REQD	QTY REQD -2	QTY REQD -1	CODE IDENT NO	PART OR IDENTIFYING NUMBER	NOMENCLATURE OR DESCRIPTION	ZONE	MATERIAL AND SPECIFICATION	HT TR	FINISH	PT MK	SER BASE NUMBER	REV LTR
				2			8	BINDER		2.00 × 10.00 [9]					
					1		7	FILLER		3.00 × 2.70 [8] [6]					
					2		6	END FITTING		.080 × 3.00 × 4.20 [1] [4] [7]					
					2		5	END FITTING		.080 × 2.00 × 2.75 [1] [4] [7]					
				2	-		-4	TAPE		2.00 × 10.00 [2]					
				1	-		-3	TAPE		2.00 × 12.75 [2]					
				-	1		-2	TAPE ASSEMBLY		[3] [6] [7]					
					-		-1	SUPPORT STRAP ASSEMBLY		[7]					

DIMENSIONING & TOLERANCING PER ANSI (USASI) Y14.5
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES: ANGLES ±
DECIMALS .XX ± .03
DECIMALS .XXX ± .010

CONTRACT NUMBER NAS3-15848
DRN D.L. BARCLAY 6/18/73
ENGR D.L. BARCLAY 7/10/73

THE BOEING COMPANY
CORPORATE OFFICES SEATTLE, WASHINGTON

SUPPORT STRAP ASSEMBLY - HALF SCALE LH_2 TEST MODEL

SIZE J CODE IDENT NO 81205 SK2-5085-151
SCALE NOTED SH 1 OF 1

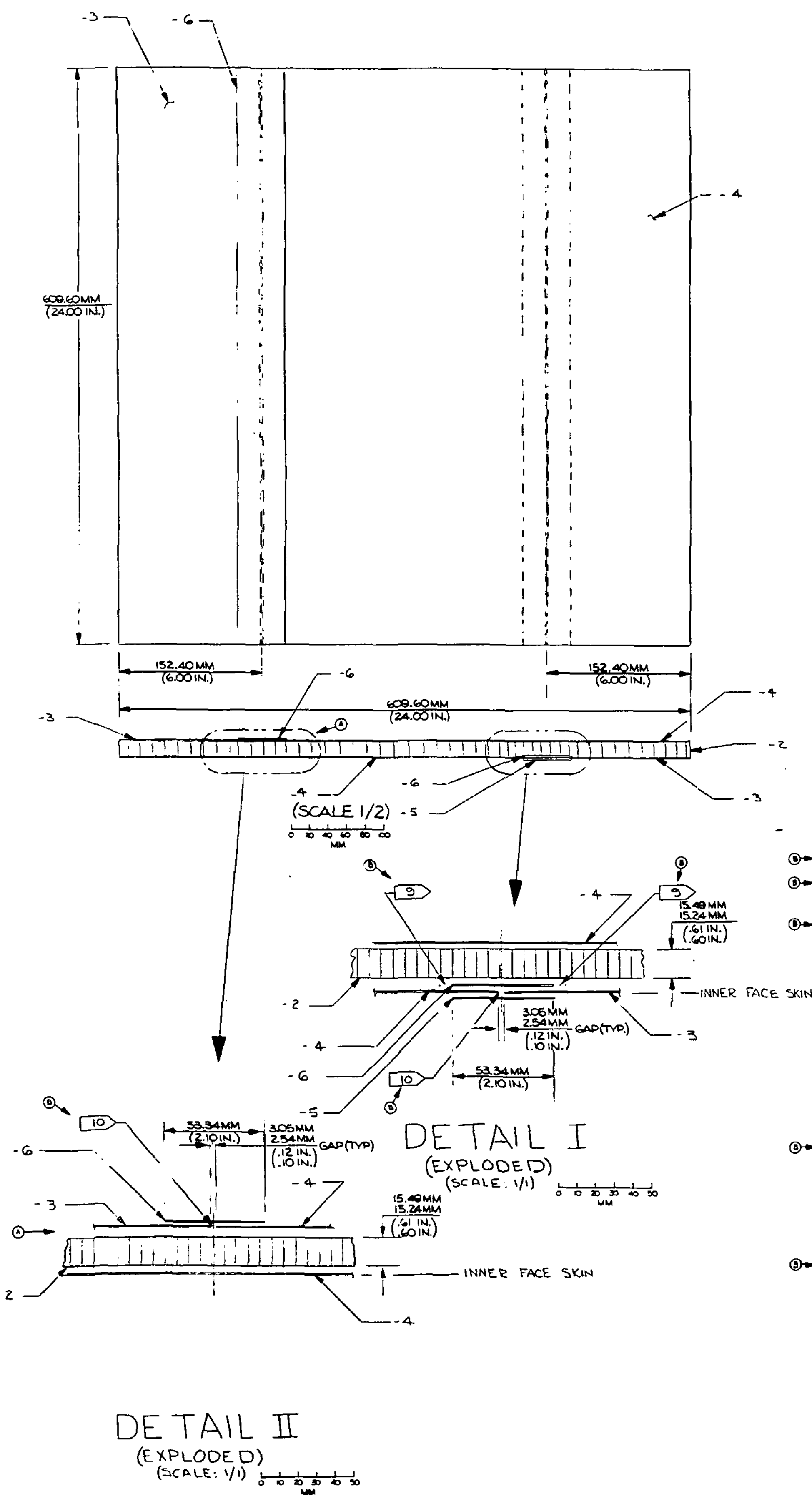
DWG ORIG BY (ORG) 2-5520

FASTENER CODES

APPLICATION: PART NUMBER | NEXT ASSY | USED ON | EFFECTIVITY | DWG BH NUMBER | REV LTR

Figure D-31

SK2-5081-151 B



ASSEMBLY PROCEDURE

1. ASSEMBLE INNER FACE SKINS -3 & -4 & STRIP -5 PER 5
2. BOND STRIP -6 PER 5
3. APPLY METLBOND 329 TO OUTER SURFACE OF THE INNER SKIN PER 3. ASSEMBLE -2 CORE & BOND PER 3 USING CAUL PLATE BETWEEN CORE & VACUUM BAG.
4. APPLY METLBOND TO OUTER SURFACE OF -2 CORE.

   PREPARE SKINS -3 & -4 PER 3. POSITION ON ASSEMBLY & BOND PER 3
5. BOND STRIP -6 TO SKINS -3 & -4 PER 5

ZONE	LTR	DESCRIPTION	DATE	APPROVED
	A	DELETED -5 STRIP ON OUTER SKIN	6/15/73	DWB
	B	ALTERED 3 & 5 ADDED 8, 9, & 10	6/26/73	DWB
	C	REVISED ASSEMBLY PROCEDURE	7/2/73	DWB

10 FILL SKIN GAP WITH XA-3919 ADHESIVE (3M CO.)

9 FARE JOINT STEP WITH A 0.25 IN. WIDE FILLET USING EA934 ADHESIVE (HYSOL DIVISION, THE DEXTER CORP).

8 CLEAN METAL DETAILS AS FOLLOWS:
a) VAPOR DEGREASE FLEX-CORE.
b) CHEM CLEAN ALL METAL DETAILS EXCEPT CORE.
c) SAND WITH 400 GRIT SANDPAPER ALL SURFACES NOT PRIMED OR BONDED IMMEDIATELY AFTER CHEM CLEANING.
d) SOLVENT CLEAN ALL PARTS WITH BMS 11-7 PRIOR TO PRIMING OR BONDING.

7 CURE BOND AT 450°K (350°F) FOR 1 HOUR AT 101.4 KN/m² (14.7 PSI) VACUUM PRESSURE

6 ALL RAW MATERIALS & ASSEMBLY SHALL BE PROTECTED FROM OIL & PARTICLE CONTAMINATION. ASSEMBLY SHALL BE DONE IN A DUST FREE ROOM.

5 CLEAN PER 8. BOND WITH XA-3919 ADHESIVE (3M CO). APPLY BY BRUSH COATING BOTH SURFACES. AIR DRY FOR 15 MIN FOLLOWED BY A 45 MIN DRYING CYCLE AT 380°K (225°F) CURE BOND PER 7.

4 1100-H18 ALUM FOIL PER QQ-A-250/1

3 CLEAN PER 8. PRIME WITH METLBOND 329, TYPE 2. APPLY METLBOND 329 ADHESIVE, NARMCO MATERIALS DIV, WHITTAKER CORP. CURE BOND PER 7.

2 FLEX-CORE 5056/F40-.0014, 33 6kg/m³ (2.1 lb/ft³) ALUMINUM HONEYCOMB, HEXCEL PRODUCTS INC.

1 2024-T81 ALUM PER QQ-A-250/5

QTY REQD	PART OR IDENTIFYING NUMBER	NOMENCLATURE OR DESCRIPTION	MATERIAL AND SPECIFICATION
2	-6	STRIP	.012 × 2.1 × 24.0 ALUM SHEET 1 5
1	-5	STRIP	.003 × 2.1 × 24.0 ALUM FOIL 4 5
2	-4	SKIN	.012 × 18.0 × 24.0 ALUM SHEET 1
2	-3	SKIN	.012 × 6.0 × 24.0 ALUM SHEET 1
1	-2	CORE	.600 × 24.0 × 24.0 FLEX-CORE 2 3
-	-1	SPECIMEN PANEL ASSEMBLY	

PARTS LIST

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES
DECIMALS .XX ± .02

CONTRACT NUMBER NAS3-15848
DRN D.L. BARCLAY 6-22-3
ENGR D.L. BARCLAY 6-22-3

THE BOEING COMPANY
CORPORATE OFFICES SEATTLE, WASHINGTON

SANDWICH BEAM & EDGEWISE COMPRESSION SPECIMEN HALF SCALE LH_2 TEST MODEL

SIZE J CODE IDENT NO 81205 SK2-5085-152

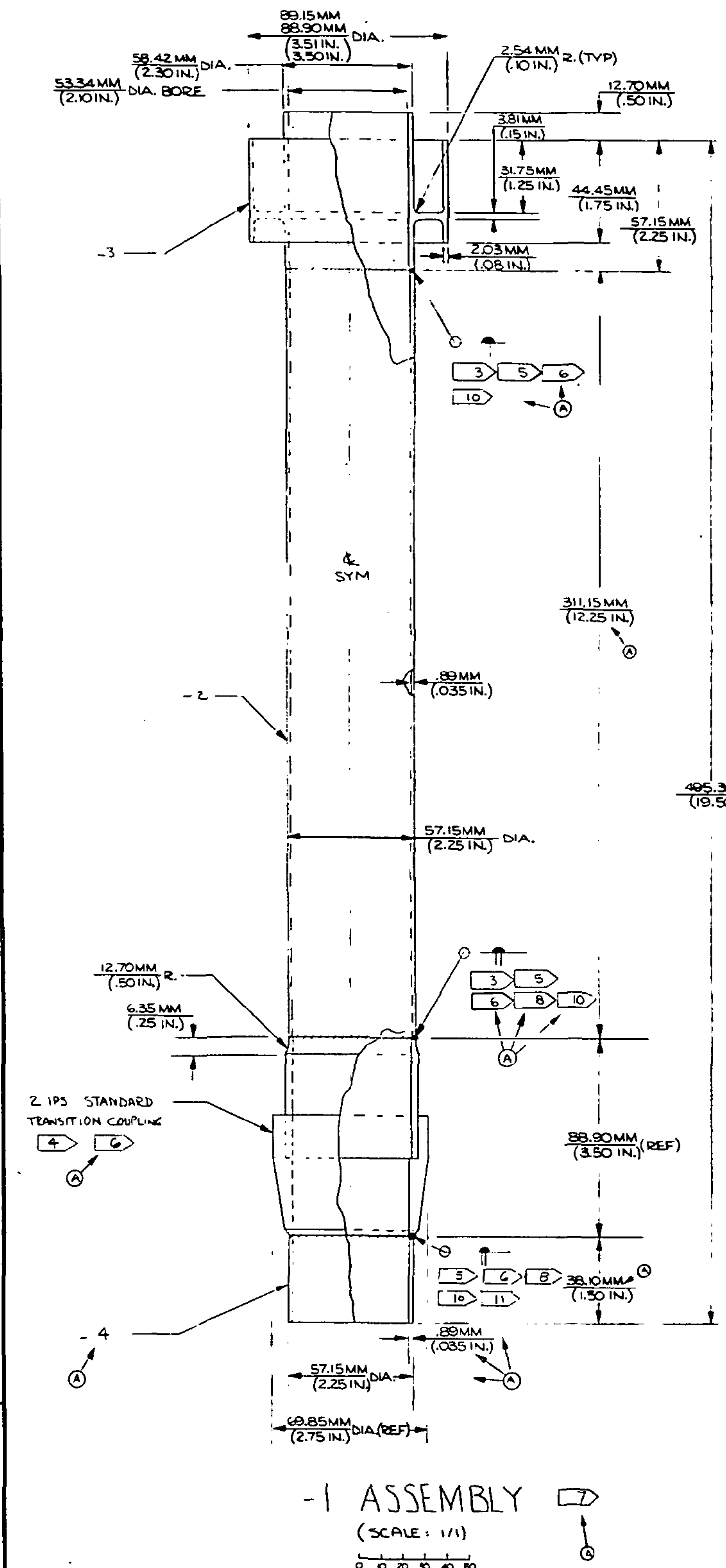
SCALE NOTED

DWG ORIG BY (ORG) 2-5520

SK2-5085-152 B

Figure D-32

SK5-2082-125



NOTES

~~1. SPECIFICATIONS AND STANDARDS FOR THE CONTROL OF MANUFACTURING OPERATIONS (AS APPLICABLE): SURFACE ROUGHNESS SYMBOLS PER BACD 2007; WELDING AND BRAZING SYMBOLS PER BACD 2009; FORM, STRAIGHTEN & SUBMETAL PARTS PER BAC 5300; MATERIAL SUBSTITUTIONS & EQUIVALENTS PER BAC 5008; PART MARKING PER BAC 5307; BOLT & NUT INSTALLATION PER BAC 5009; FINISH CODES PER DOCUMENT D2-5000; RIVET INSTALLATION & SYMBOLS PER BAC 5004~~

(A) → 11 FISION WELD PER BAC 5935 CLASS A. FILLER WIRE ER 4043 PER QQ-R-566 TYPE 4043 OR MIL-E-16053 TYPE 4043. INSPECT PER 10

(A) → 10 RADIOGRAPHIC INSPECT PER BAC 5915. PENETRANT INSPECTION SHALL NOT BE USED

(A) → 9 6061-T6 ALUMINUM ALLOY TUBE PER QQ-A-200/5C OR WW-T-700/6D

(A) → 8 SEE SPECIAL PRECAUTIONS (SUPPLIED BY ENGINEERING) FOR WELDING TO TRANSITION COUPLING

(A) → 7 WELD ASSEMBLY TO BE STRAIGHT WITHIN .06.

(A) → 6 COLD SHOCK EACH END OF ASSEMBLY INCLUDING WELD JOINT WITH LIQUID NITROGEN PRIOR TO HELIUM LEAK CHECK

(A) → 5 LEAK RATE NOT TO EXCEED 1×10^{-9} STD CC/ HELIUM PER SECOND.

4 BI-BRAZE CORP PART NUMBER

(A) → 3 WELD PER BAC 5930 CLASS A. INSPECT PER 10

2 321 CRES BAR PER QQ-S-763

1 321 CRES TUBE PER MIL-T-8808

REV STATUS

SH	LTR

REVISIONS

ZONE	LTR	DESCRIPTION	DATE	APPROVED
	A	ADDED 6, 7, 8, 9, 10 & 11 PART -4 & DIMS 1.50, 2.25 & .035. ALTERED 3 & 5 DIM 12.25 WAS 13.75	12-5-73	

PARTS LIST

QTY REQD	QTY REQD	QTY REQD	QTY REQD	QTY REQD	QTY REQD -1	CODE IDENT NO	PART OR IDENTIFYING NUMBER	NOMENCLATURE OR DESCRIPTION	ZONE	MATERIAL AND SPECIFICATION	HT TR	FINISH	PT MK	SER BASE NUMBER	REV LTR
					1			2 IPS STANDARD TRANSITION COUPLING		2 IPS SCHEDULE 10, 6061 ALUM TO 304 CRES 4					
					1		-4	TUBE		2.25 OD × .035 WALL × 1.50 LG ALUM TUBE 9					
					1		-3	FITTING		3.51 DIA × 2.75 LG CRES BAR 2					
					1		-2	TUBE		2.25 OD × .035 WALL × 13.75 LG CRES TUBE 1					
					-		-1	INLET TUBE ASSEMBLY							

DIMENSIONING & TOLERANCING PER ANSI (USASI) Y14.5

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES

TOLERANCES: ANGLES ±
DECIMALS .XX ± .02
DECIMALS .XXX ±
RIVET & BOLT EDGE MARGIN ±.05
BEND RADII ±.01 ON .03 & .06
±.03 ON .08 & GREATER
SHEET METAL CORNER RADII
INT .16 $^{.19}_{.16}$ EXT .22 $^{.25}_{.00}$

DATA REVIEW: DWG QUAL; STRUCT; MATL & PRCS

CHANGE/ITEM NUMBER

CONTRACT NUMBER NAS 3-15848

DWN D.L. BARCLAY 7-23-73
CHK
ENGR D.L. BARCLAY 10/15/73
GRO
PROJECT APPROVAL

THE BOEING COMPANY
CORPORATE OFFICES SEATTLE, WASHINGTON 98124

INLET TUBE ASSEMBLY HALF SCALE LH_2 TEST MODEL

SIZE J CODE IDENT NO 81205 SK2-5085-153

SCALE NOTED SH 1 OF 1

FASTENER CODES

PART NUMBER	NEXT ASSY	USED ON	EFFECTIVITY	DWG SH NUMBER	REV LTR

APPLICATION

DWG ORIG BY (ORG) 2-5520

SK2-5085-153 A

DRAWING RECORDS CLERK

2KS-2082-123-1

Figure D-33

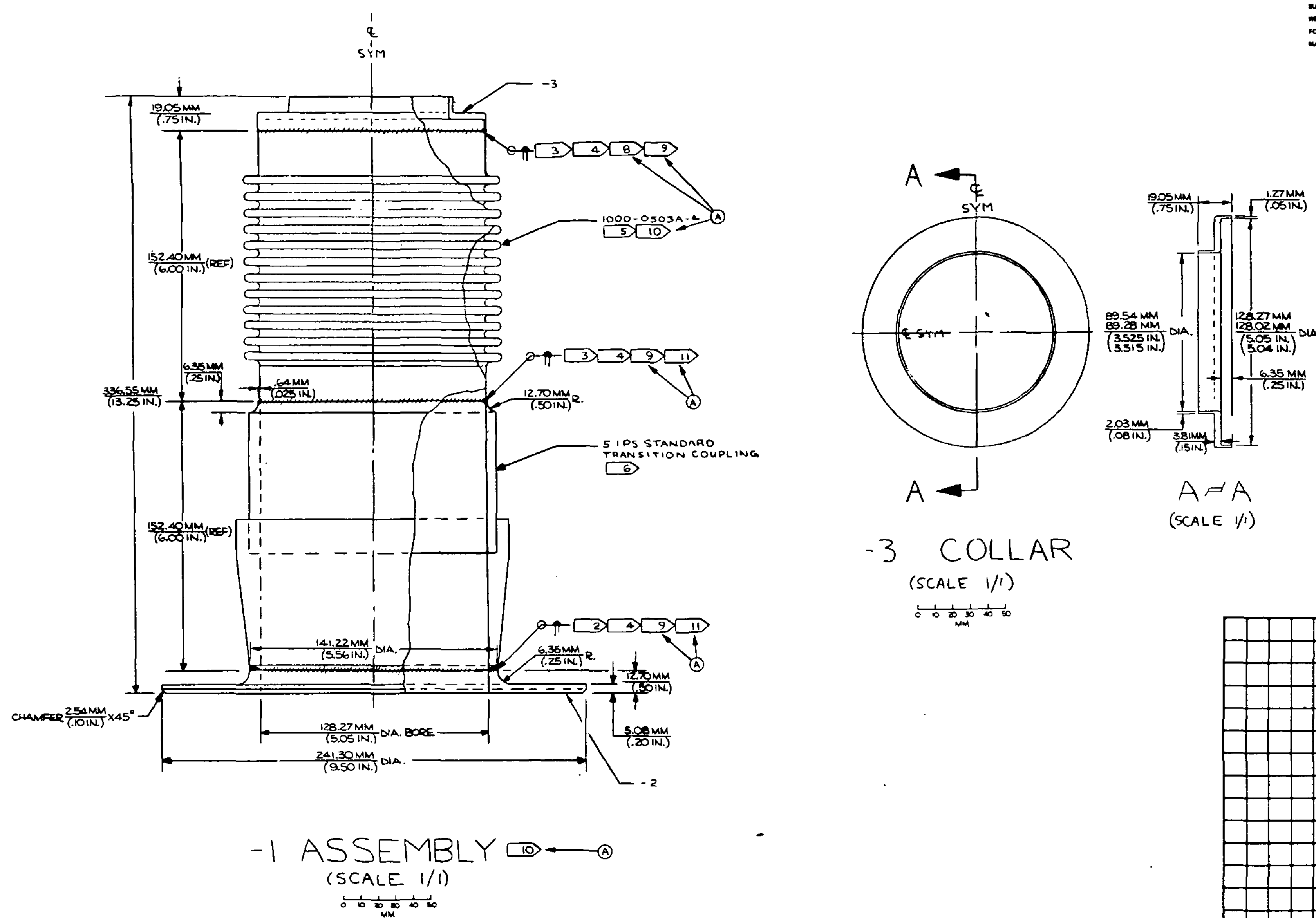
NOTES

1. ~~SPECIFICATIONS AND STANDARDS FOR THE CONTROL OF MANUFACTURING OPERATIONS (AS APPLICABLE):~~
~~SURFACE ROUGHNESS SYMBOLS PER BACD 2007 — PART MARKING PER BAC 5307~~
~~WELDING AND BRAZING SYMBOLS PER BACD 2020 — BOLT & NUT INSTALLATION PER BAC 5009~~
~~FORM, STRAIGHTEN & FIT METAL PARTS PER BAC 5300 — FINISH CODES PER DOCUMENT D2-6000~~
~~MATERIAL SUBSTITUTIONS & EQUIVALENTS PER BAC 5008 — RIVET INSTALLATION & SYMBOLS PER BAC 5004~~

REV STATUS SH	LTR

REVISIONS

ZONE	LTR	DESCRIPTION	DATE	APPROVED
	A	ADDED 8, 9, 10, & 11 ALTERED 2 3 & 4	12-5-73	[illegible]



11 SEE SPECIAL PRECAUTIONS (SUPPLIED BY ENGINEERING) FOR WELDING TO TRANSITION COUPLING

10 CAUTION: SPECIAL HANDLING IS REQUIRED TO PREVENT DAMAGE TO THE THIN WALLED BELLOWS

9 RADIOGRAPHIC INSPECT PER BAC 5915. PENETRANT INSPECTION SHALL NOT BE USED

8 COLD SHOCK THE WELD JOINT WITH LIQUID NITROGEN PRIOR TO HELIUM LEAK CHECK DO NOT COLD SHOCK THE BELLOWS CONVOLUTES 10

7 321 CRES BAR PER QQ-S-763

6 BI-BRAZE CORP PART NUMBER

5 AVICA CORP PART NUMBER

4 LEAK RATE NOT TO EXCEED 1×10^{-9} STD CC/ HELIUM PER SECOND

3 WELD PER BAC 5930 INSPECT PER 9

2 FUSION WELD PER BAC 5935 CLASS A. FILLER WIRE ER 4043 PER QQ-R-566 TYPE 4043 OR MIL-E-16053 TYPE 4043. INSPECT PER 9

1 6061 T6 ALUM PLATE PER QQ-A-250/11

PARTS LIST

QTY REQD	QTY REQD	QTY REQD	QTY REQD	QTY REQD	QTY REQD	CODE IDENT NO	PART OR IDENTIFYING NUMBER	NOMENCLATURE OR DESCRIPTION	ZONE	MATERIAL AND SPECIFICATION	HT TR	FINISH	PT MK	SER BASE NUMBER	REV LTR
					1		1000-0503A-4	BELLOWS		5					
					1			5 IPS STANDARD TRANSITION COUPLING		5 IPS SCHEDULE 40 6061 ALUM TO 304 CRES 6					
					1		-3	COLLAR		5.15 DIA x .75 LG CRES BAR 7					
					1		-2	COLLAR		9.50 DIA x .50 LG ALUM PLATE 1					
					–		-1	VACUUM JACKET CLOSEOUT (INLET) ASSEMBLY							
					1										

PART NUMBER	NEXT ASSY	USED ON	EFFECTIVITY	DWG IN NUMBER	REV LTR

APPLICATION

FASTENER CODES

DIMENSIONING & TOLERANCING PER ANSI (USASI) Y14.5
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES: ANGLES ± 1/2°
DECIMALS .XX ± .02
DECIMALS .XXX ±
RIVET & BOLT EDGE MARGIN ±.05
BEND RADII ±.01 ON .03 & .06
±.03 ON .09 & GREATER
SHEET METAL CORNER RADII INT .16 $^{.19}_{.16}$ EXT .22 $^{.25}_{.00}$

DATA REVIEW: DWG QUAL; STRUCT; MATL & PROC; CHANGE/ITEM NUMBER

CONTRACT NUMBER NAS 3-15848
DWN D.L. BARCLAY 7-26-7[illegible]
CHK
ENGR D.L. BARCLAY 1/16/7[illegible]
ORG
PROJECT APPROVAL

THE BOEING COMPANY
CORPORATE OFFICES SEATTLE, WASHINGTON

VACUUM JACKET CLOSEOUT (INLET) ASSEMBLY - HALF SCALE LH_2 TEST MODEL

SIZE J — CODE IDENT NO 81205 — SK2-5085-154
SCALE NOTED — SH 1 OF 1

DWG ORIG BY (ORG) 2-5520

DRAWING RECORDS CLERK

SK2-5085-154 A 1

Figure D-34

NOTES

1. SPECIFICATIONS AND STANDARDS FOR THE CONTROL OF MANUFACTURING OPERATIONS (AS APPLICABLE):

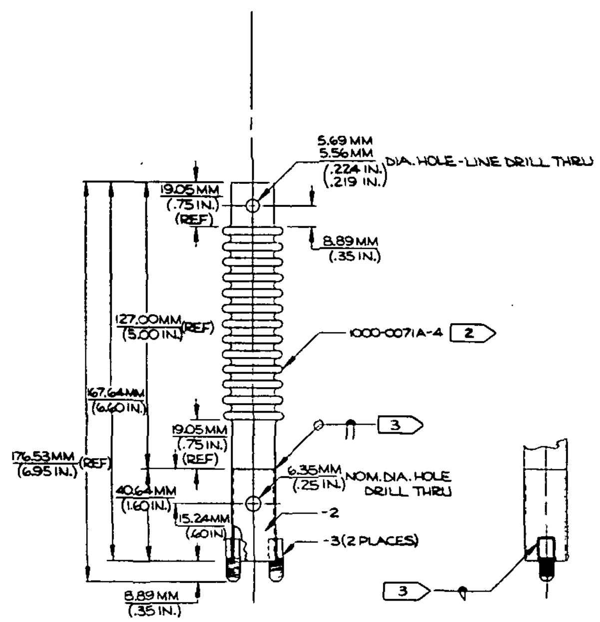
FORM, STRAIGHTEN & FIT METAL PARTS PER BAC 5300 — BOLT & NUT INSTALLATION PER BAC 5009

RIVET INSTALLATION & SYMBOLS PER BAC 5004 — PART MARKING PER BAC 5307

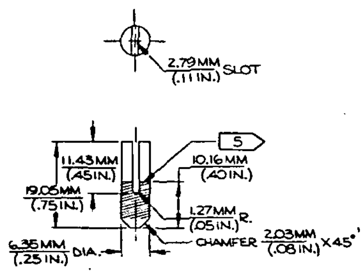
FINISH CODES PER DOCUMENT D2-5000

REV STATUS SH	LTR

ZONE	LTR	DESCRIPTION	DATE	APPROVED



-1 ASSEMBLY
(SCALE 1/1)



-3
(SCALE 2/1)

5 THREAD UNF-3A .25-28

4 321 CRES BAR PER QQ-S-763

3 WELD PER BAC 5930 CLASS C

2 AVICA CORPORATION PART NUMBER

1 321 CRES TUBE PER MIL-T-8504, OR MIL-T-8808, OR BMS 7-41

PART NUMBER	NEXT ASSY	USED ON	EFFECTIVITY	DWG SH NUMBER	REV LTR
APPLICATION					

FASTENER CODES

PARTS LIST

QTY REQD	QTY REQD	QTY REQD	QTY REQD	QTY REQD	QTY REQD -1	FIND NUMBER	PART OR IDENTIFYING NUMBER	NOMENCLATURE OR DESCRIPTION	ZONE	MATERIAL AND SPECIFICATION	CODE IDENT NO	HT TR	FINISH	PT MK	REV LTR
					1		1000-0071A-4	BELLOWS		2					
					2		-3	STUD		.25 DIA. X .75 LG CRES BAR 4					
					1		-2	TUBE		.75 DIA. X .035 WALL CRES TUBE 1					
					—		-1	SIMULATED PLUMBING LINE ASSEMBLY							

DIMENSIONING & TOLERANCING PER ANSI Y14.5
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES: ANGLES ±
DECIMALS .XX ± .02
DECIMALS .XXX ±
RIVET & BOLT EDGE MARGINS
BEND RADII ±.01 ON .00 & .00
±.03 ON .09 & GREATER
SHEET METAL CORNER RADII
INT .10 .15 EXT .25 .09

REVIEW & APPROVAL
DWG QUAL
STRUCT
MATL & PROC
CHANGE/ITEM NUMBER

CONTRACT NUMBER NAS3-15848
DRN D.M. DUNNING 6/19/76
CHK
ENGR D.L. BARCLAY 4/22/76
ORG
PROJECT APPROVAL

THE BOEING COMPANY
CORPORATE OFFICES SEATTLE, WASHINGTON

SIMULATED PLUMBING LINE ASSY. HALF SCALE LH_2 TEST MODEL

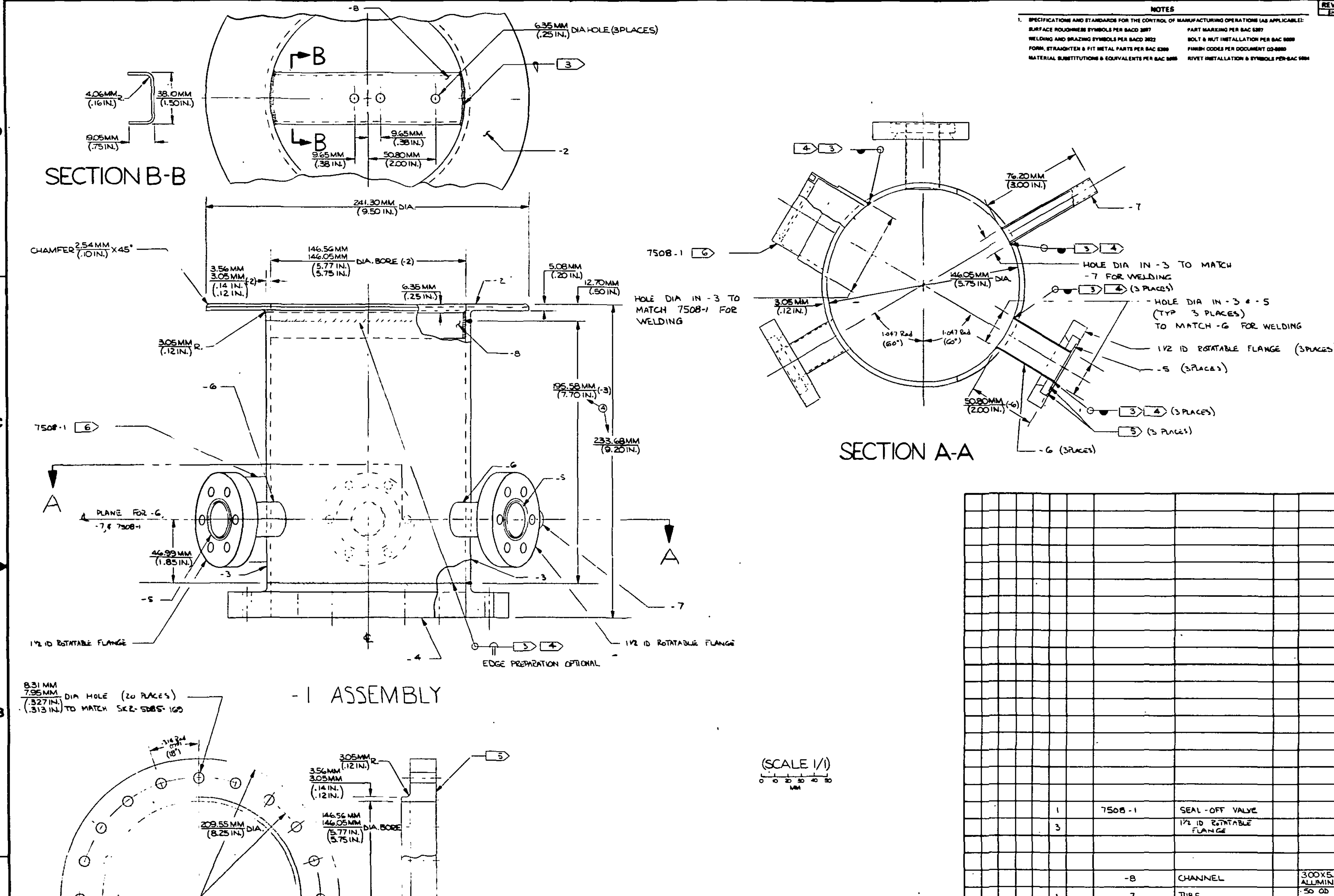
SIZE J CODE IDENT NO 81205 SK2-5085-155

SCALE NL ED SH OF

DWG ORIG BY (ORG) 2-5520

SK2-5085-155 REV

Figure D-35



6 CRYOLAB PART NUMBER

5 32/ SURFACE FINISH (VACUUM SEALING SURFACE)

4 LEAK RATE NOT TO EXCEED 1x10⁻⁹ STD CC/HELIUM PER SECOND

3 FUSION WELD PER BAC 5935 CLASS B. FILLER WIRE ER 4043 PER QQ-R-566 TYPE 4043 OR MIL-E-16053 TYPE 4043. PENETRANT INSPECTION SHALL NOT BE USED.

2 6061 T6 ALUM SHEET OR PLATE PER QQ-A-250/11

1 6061 T6 ALUM TUBE PER QQ-A-200/9C OR WW-T-700/6D

NOTES

1. SPECIFICATIONS AND STANDARDS FOR THE CONTROL OF MANUFACTURING OPERATIONS (AS APPLICABLE):
   - SURFACE ROUGHNESS SYMBOLS PER BACD 2007
   - WELDING AND BRAZING SYMBOLS PER BACD 2022
   - FORM, STRAIGHTEN & FIT METAL PARTS PER BAC 5300
   - MATERIAL SUBSTITUTIONS & EQUIVALENTS PER BAC 5005
   - PART MARKING PER BAC 5307
   - BOLT & NUT INSTALLATION PER BAC 5009
   - FINISH CODES PER DOCUMENT D2-5000
   - RIVET INSTALLATION & SYMBOLS PER BAC 5004

REVISIONS

ZONE	LTR	DESCRIPTION	DATE	APPROVED
	A	DIMENSION 9.20 WAS 5.20 DIMENSION 7.70 WAS 3.70	2/19/74	DJB
	B	ADDED -8	4/22/74	DJB

PARTS LIST

QTY REQD -1	CODE IDENT NO	PART OR IDENTIFYING NUMBER	NOMENCLATURE OR DESCRIPTION	ZONE	MATERIAL AND SPECIFICATION		REV LTR
1		7508-1	SEAL-OFF VALVE			6	
3			1½ ID ROTATABLE FLANGE				
		-8	CHANNEL		3.00X5.80X.08 ALUMINUM SHEET	2	B
1		-7	TUBE		.50 OD x .035 WALL x 3.00 LG ALUM TUBE	1	
3		-6	TUBE		1.00 OD x .049 WALL x 2.00 LG. ALUM TUBE	1	B
3		-5	INSERT		1.50 DIA x .25 THK ALUM PLATE		
1		-4	COLLAR		8.25 DIA x 1.00 ALUMINUM PLATE	2	B
1		-3	CYLINDER		6.00 OD x .12 WALL x 7.70 LG ALUM TUBE	1	A
1		-2	COLLAR		9.50 DIA x .50 THK ALUM PLATE	2	
-		-1	VACUUM JACKET CLOSEOUT ASSEMBLY				

DIMENSIONING & TOLERANCING PER ANSI (USASI) Y14.5
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES: ANGLES ± DECIMALS .XX ± .02 DECIMALS .XXX ±

CONTRACT NUMBER NAS3-15848
DRN D.L. BARCLAY 7-31-73
ENGR D.L. BARCLAY 1-3-74

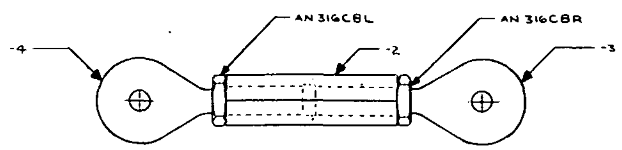
THE BOEING COMPANY, CORPORATE OFFICES, SEATTLE, WASHINGTON

VACUUM JACKET CLOSEOUT (SIMULATED PLUMBING LINE) ASSEMBLY HALF SCALE LH_2 TEST MODEL

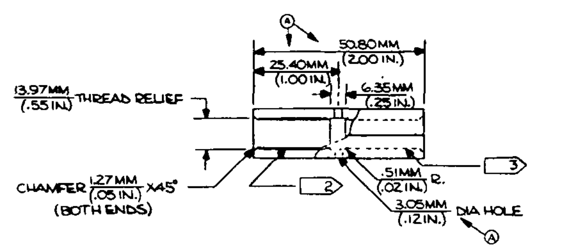
SIZE J CODE IDENT NO 81205 SK2-5085-156
SCALE 1/1 SH 1 OF 1
DWG ORIG BY (ORG) 2-5520

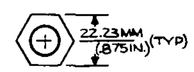
SK2-5085-156 B

Figure D-36

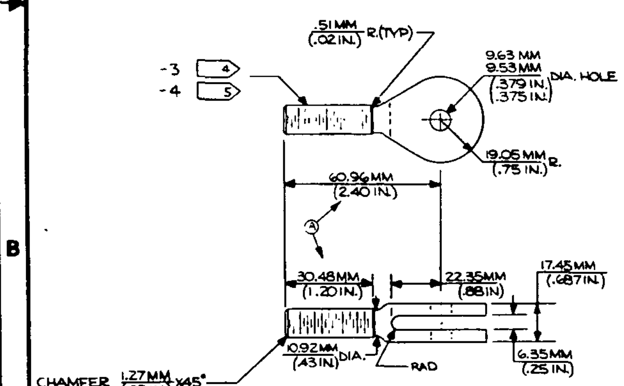


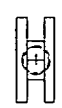
-1 ASSEMBLY





-2 TURN BUCKLE BODY





-3 & -4 CLEVIS END

(SCALE 1/1)

0 10 20 30 40 50 MM

NOTES

1. SPECIFICATIONS AND STANDARDS FOR THE CONTROL OF MANUFACTURING OPERATIONS (AS APPLICABLE):

FORM, STRAIGHTEN & FIT METAL PARTS PER BAC 5300 — BOLT & NUT INSTALLATION PER BAC 5009

RIVET INSTALLATION & SYMBOLS PER BAC 5004 — PART MARKING PER BAC 5307

FINISH CODES PER DOCUMENT D2-8000

1. 321, 302, OR 304 CRES BAR PER QQ-S-763
2. THREAD UNF-3B 1/2 -20 RIGHT HAND TO CENTER
3. THREAD UNF-3B 1/2 -20 LEFT HAND TO CENTER
4. THREAD UNF-3A 1/2 -20 RIGHT HAND
5. THREAD UNF-3A 1/2 -20 LEFT HAND

REV STATUS

LH	LTR

REVISIONS

ZONE	LTR	DESCRIPTION	DATE	APPROVED
	A	ALTERED DIMENSIONS -2 2.00 WAS 3.00 1.00 WAS 1.50 -3 & -4 2.40 WAS 2.75 1.20 WAS 1.55	4/17/74	[illegible]

PARTS LIST

QTY REQD	QTY REQD	QTY REQD	QTY REQD	QTY REQD	QTY REQD -1	FIND NUMBER	PART OR IDENTIFYING NUMBER	NOMENCLATURE OR DESCRIPTION	ZONE	MATERIAL AND SPECIFICATION	CODE IDENT NO	HT TR	FINISH	PT MK	REV LTR
					1		AN316C8L	JAM NUT							
					1		AN316C8R	JAM NUT							
					1		-4	CLEVIS END LH THREAD		.75×3.50×1.50 1					
					1		-3	CLEVIS END RH THREAD		.75×3.50×1.50 1					
					1		-2	TURNBUCKLE BODY		.875 HEX×3.00 1					
					—		-1	TURNBUCKLE ASSY.							

PART NUMBER	NEXT ASSY	USED ON	EFFECTIVITY	DWG SH NUMBER	REV LTR

APPLICATION

FASTENER CODES

DIMENSIONING & TOLERANCING PER ANSI (USASI) Y14.5

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES

TOLERANCES: ANGLES ±
DECIMALS .XX ± .02
DECIMALS .XXX ± .010
RIVET & BOLT EDGE MARGINS ±.05
BEND RADII ±.01 ON .03 & .06
±.03 ON .09 & GREATER
SHEET METAL CORNER RADII
INT .19 .16 EXT .25 .00

REVIEW & APPROVAL: DWG QUAL; STRUCT; MATL & PRCS

CHANGE/ITEM NUMBER

CONTRACT NUMBER NAS3-15848

DWN P.L.CARPENTIER 10-5-73

CHK

ENGR D.L. [illegible] 10/29/73

ORG

PROJECT APPROVAL

THE BOEING COMPANY

CORPORATE OFFICES SEATTLE, WASHINGTON 98124

TURNBUCKLE ASSEMBLY HALF SCALE LH_2 TEST MODEL

SIZE J CODE IDENT NO 81205 SK2-5085-163

SCALE 1/1 SH 1 OF 1

DWG ORIG BY (ORG) 2-5520

DRAWING RECORDS CLERK

SK2-5085-163 A

2KS-2082-163

81

Figure D-37

NOTES

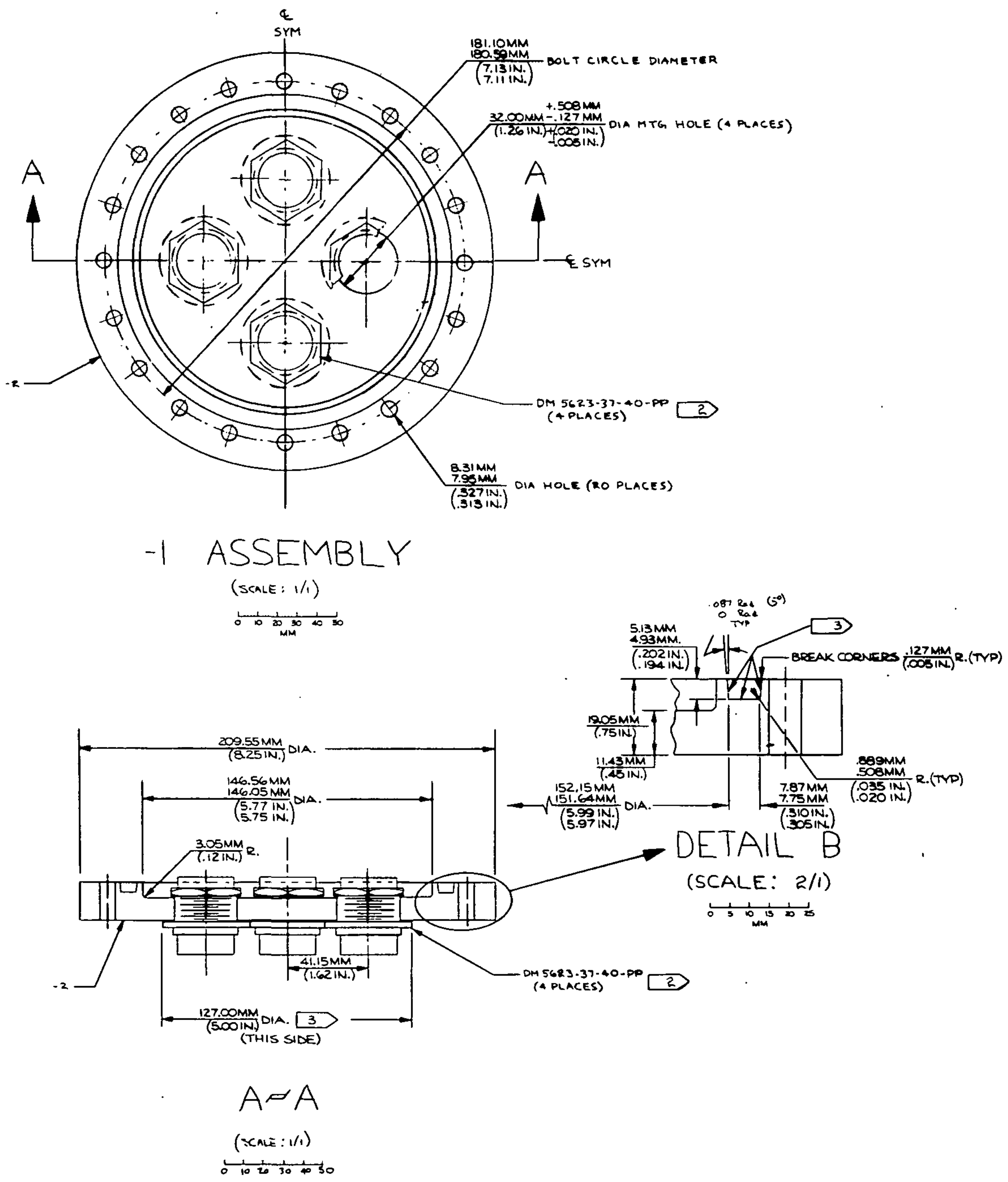
1. SPECIFICATIONS AND STANDARDS FOR THE CONTROL OF MANUFACTURING OPERATIONS (AS APPLICABLE)

FORM, STRAIGHTEN & FIT METAL PARTS PER BAC 5300 — BOLT & NUT INSTALLATION PER BAC 5009

RIVET INSTALLATION & SYMBOLS PER BAC 5004 — PART MARKING PER BAC 5307

FINISH CODES PER DOCUMENT D2 5000

REV STATUS SH	LTR	REVISIONS ZONE	LTR	DESCRIPTION	DATE	APPROVED



3 — $\sqrt[32]{}$ SURFACE FINISH (VACUUM SEALING SURFACE)

2 — DEUTSCH COMPANY PART NUMBER

1 — 6061 T6 ALUM PLATE PER QQ-A-250/11

PARTS LIST

QTY REQD	FIND NUMBER	PART OR IDENTIFYING NUMBER	NOMENCLATURE OR DESCRIPTION	ZONE	MATERIAL AND SPECIFICATION	CODE IDENT NO	HT TR	FINISH	PT MK	REV LTR
4		DM 5623-37-40-PP	RECEPTACLE CONNECTOR		2					
1		-2	COVER PLATE		8.25 × 8.25 × .75 ALUM. PLATE 1					
—		-1	COVER PLATE ASSY.							

PART NUMBER	NEXT ASSY	USED ON	EFFECTIVITY	DWG SH NUMBER	REV LTR

APPLICATION

FASTENER CODES

DIMENSIONING & TOLERANCING PER ANSI (USASI) Y14.5
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES: ANGLES ±
DECIMALS .XX ± .02
DECIMALS .XXX ±
RIVET & BOLT EDGE MARGIN ±.05
BEND RADII ±.01 ON .02 & .05, ±.03 ON .06 & GREATER
SHEET METAL CORNER RADII INT .19 .10 EXT .25 .00

REVIEW & APPROVAL: DWG QUAL; STRUCT; MATL & PRCS; CHANGE/ITEM NUMBER

CONTRACT NUMBER NAS 3-15848
DRN P.L. CARPENTIER 1/25/7?
CHK
ENGR D. BARCLAY 2/1/7?
ORG
PROJECT APPROVAL

THE BOEING COMPANY
CORPORATE OFFICES SEATTLE, WASHINGTON

COVER PLATE
VACUUM JACKET CLOSEOUT
HALF SCALE LH_2 TEST MODEL

SIZE J CODE IDENT NO 81205 SK2-5085-169

SCALE NOTED SH 1 OF 1

DWG ORIG BY (ORG) 2-5520

DRAWING RECORDS CLERK

SK2-5085-169

Figure D-38

SK5-2082-1e2

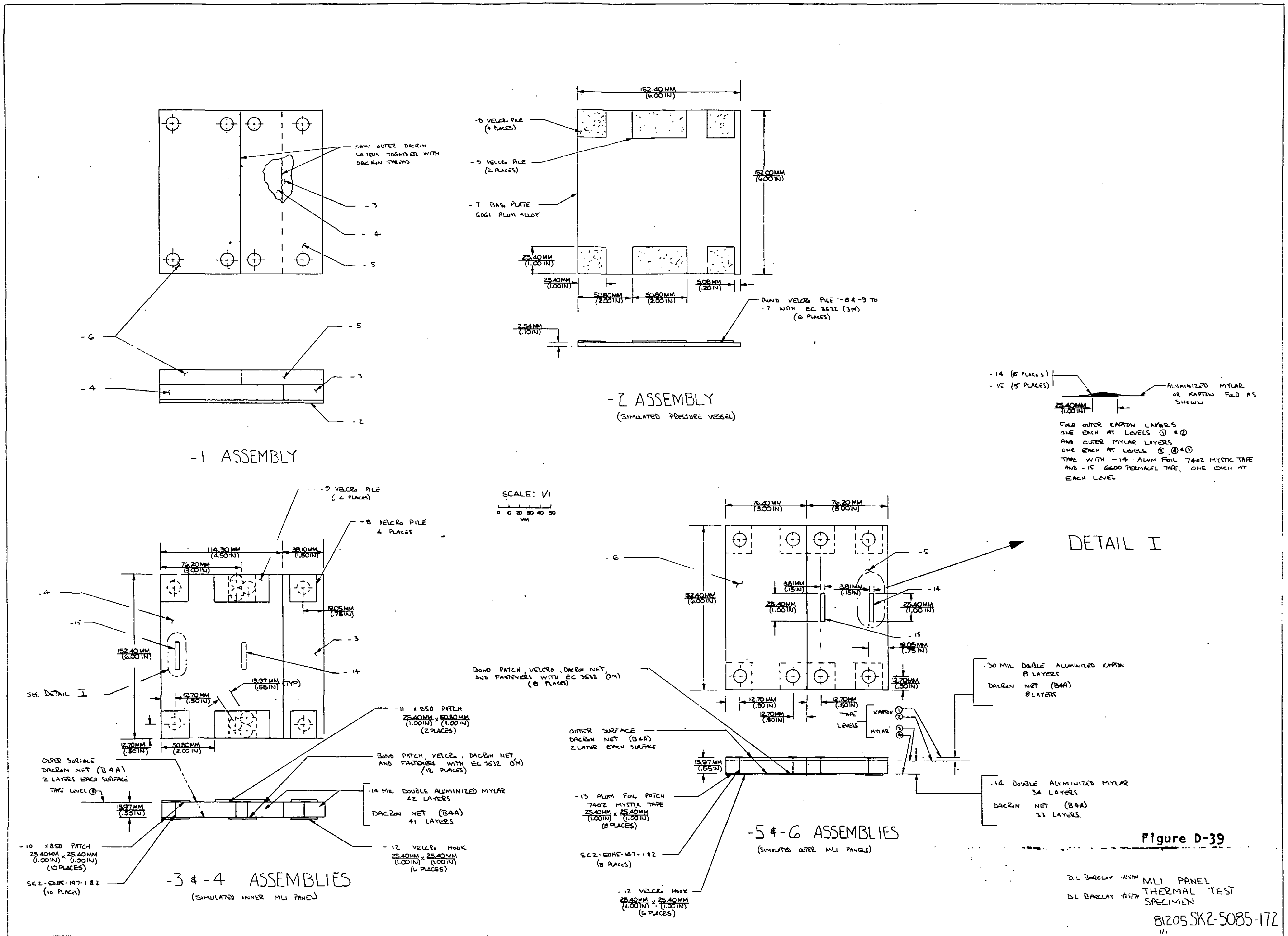
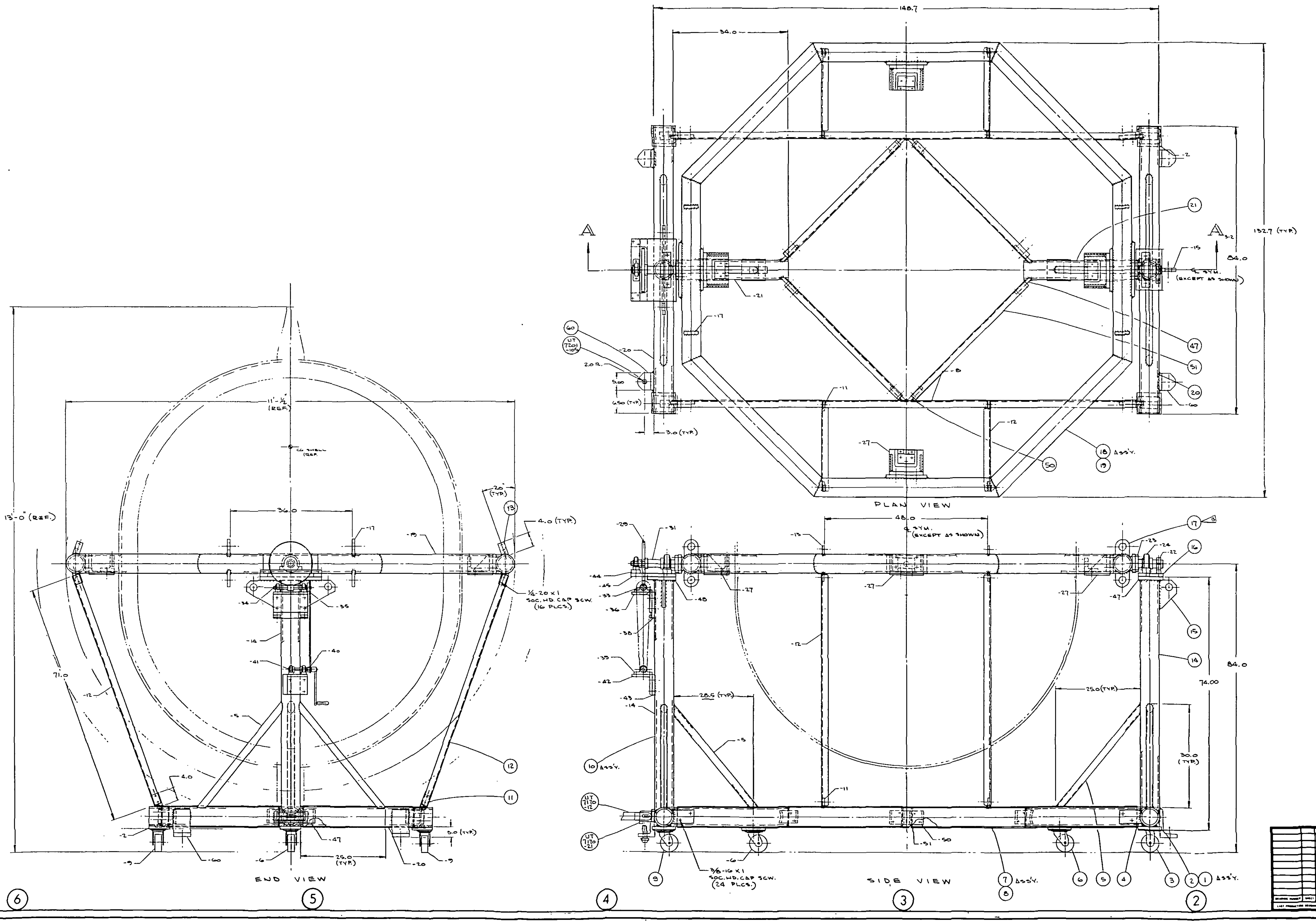

-1 ASSEMBLY
-2 ASSEMBLY
(SIMULATED PRESSURE VESSEL)
-3 & -4 ASSEMBLIES
(SIMULATED INNER MLI PANEL)
-5 & -6 ASSEMBLIES
(SIMULATED OUTER MLI PANELS)
DETAIL I
SCALE: 1/1
-7 BASE PLATE 6061 ALUM ALLOY
-8 VELCRO PILE (4 PLACES)
-9 VELCRO PILE (2 PLACES)
BOND VELCRO PILE -8 & -9 TO -7 WITH EC 3532 (3M) (6 PLACES)
SEW OUTER DACRON LAYERS TOGETHER WITH DACRON THREAD
-14 MIL DOUBLE ALUMINIZED MYLAR 42 LAYERS
DACRON NET (B4A) 41 LAYERS
-30 MIL DOUBLE ALUMINIZED KAPTON 8 LAYERS
DACRON NET (B4A) 8 LAYERS
-14 DOUBLE ALUMINIZED MYLAR 34 LAYERS
DACRON NET (B4A) 33 LAYERS
SK2-5085-147-1 & 2 (10 PLACES)
SK2-5085-147-1 & 2 (8 PLACES)
-12 VELCRO HOOK 25.40MM x 25.40MM (1.00IN) x (1.00IN) (6 PLACES)
-13 ALUM FOIL PATCH 7402 MYSTIK TAPE 25.40MM x 25.40MM (1.00IN) x (1.00IN) (8 PLACES)
-10 x850 PATCH 25.40MM x 25.40MM (1.00IN) x (1.00IN) (10 PLACES)
-11 x850 PATCH 25.40MM x 50.80MM (1.00IN) x (1.00IN) (2 PLACES)
BOND PATCH, VELCRO, DACRON NET, AND FASTENERS WITH EC 3532 (3M) (12 PLACES)
BOND PATCH, VELCRO, DACRON NET, AND FASTENERS WITH EC 3532 (3M) (8 PLACES)
OUTER SURFACE DACRON NET (B4A) 2 LAYERS EACH SURFACE
FOLD OUTER KAPTON LAYERS ONE EACH AT LEVELS ① & ② AND OUTER MYLAR LAYERS ONE EACH AT LEVELS ③, ④ & ⑤ TAPE WITH -14 ALUM FOIL 7402 MYSTIC TAPE AND -15 6600 PERMACEL TAPE, ONE EACH AT EACH LEVEL
ALUMINIZED MYLAR OR KAPTON FOLD AS SHOWN
D.L. BARCLAY MLI PANEL THERMAL TEST SPECIMEN
81205 SK2-5085-172

Figure D-39



FUNCTION OF TOOL

TO HOLD TANK FOR ASSEMBLY & TEST.

NOTES

BREAK SHARP EDGES & CORNERS.
SCALE DWG. FOR NON-CRITICAL DIMS. NOT GIVEN.
IDENTIFY PER TPS 40, M41-01.
WELD & STRESS RELIEVE STEEL PER TPS 28.
WELD ALUMINUM PER TPS 36.
SCREWS & DOWELS AS REQ'D.
-12 & -51 DETAILS & -7 & -27 ASS'YS. REMOVABLE.

1 (2-3) ATTACH PER TPS 37

2 PRIME & PAINT STEEL STRUCTURE SEAFOAM GREEN, LIFT LUGS HIGH VISIBILITY YELLOW.

3 STENCIL ON OR NEAR LUGS - "LIFT YOKE ASS'Y. ONLY," IN BLACK LETTERS 1/2" HIGH.

ASSY USED ON	DETAIL NO	QUANTITY	NAME OF DETAIL	ZONE	MATERIAL	STOCK SIZE
1/10	60	2/2	ANGLE	4	MS ANG	8x8x1x5
1/10	UT 7201	2/2	LEVELING SCREW	4	-105	
10	59	1	KEY	7-2	CRS	1/4 x 1/4 x 2 1/2
10	58	1	KEY	5-2	CRS	1/4 x 1/4 x 1 3/4
10	57	2	KEY	6-2	CRS	3/16 x 3/16 x 1
18	UT 7028	4	DOWEL	7-2	-8-1 3/4	
18	UT 7039	8	L-PIN	3-2	-65A1-2	
27	UT 7028	8	DOWEL	2-3	-6-1 1/2	
28	56	4	INDEX PIN	2-3	DR	1/8 DIA. x 3 1/2
28	55	4	BLOCK	2-3	HRS	4x4x5
28	54	4	CAP	2-3	HRS	1 1/2 x 1 1/2 x 5
10	UT 7170	1	TRAILER TONGUE	4	-12	
10	UT 7170	1	MOUNTING BRACKET	4	-21	
27	53	8	GUSSET	2-3	HRS	5/8 x 2 x 5
27	52	4	SUPPORT ANGLE	2-3	MS ANG.	8x8x1x10
	51	4	BRACE	2	CHAN. AL. 6061-T6	6x3# x 48
7	50	4	PLATE	2	AL. 6061-T651	3/4 x 4 x 6
10	49	2	BLOCK	6-2	CRS	5/8 x 5/8 x 2
10	48	1	PLATE	5-2	HRS	1 x 8 1/2 x 18
1/10	47	2/2	PLATE	2	HRS	3/4 x 4 x 7
10	46	2	SPACER	7-2	HRS	1 1/4 DIA. x 2
|	45	1	PLATE	4-2	HRS	1 x 13 1/2 x 18 1/2
|	44	1	SUPPORT	4-2	HRS	1 1/4 x 2 1/2 x 18
|	43	1	PLATE	6-2	HRS	3/4 x 6 x 7 1/2
|	42	1	SUPPORT	|	MS ANG	6x6x 3/4 x 6
|	41	1	SHAFT	|	DR RD	3/4 DIA. x 8
|	40	1	SPROCKET	|	BOSTON #HKSU 10-2 3/4 BRG ●	
|	39	4	PILLOW BLOCK	|	BOSTON #06910-4H ●	
|	38	1	PLATE	|	HRS	3/4 x 7 1/4 x 10
|	37	1	CHAIN	|	BOSTON #41 x 5 FT. ●	
|	36	1	SUPPORT	|	MS ANG	6x6x 3/4 x 10
|	35	1	SPROCKET	|	BOSTON #HKSU 24-1 3/4 BRG ●	
|	34	1	SHAFT	|	DR RD	3/4 DIA. x 12
|	33	1	WORM	|	BOSTON #H1076 ●	
10	32	2	LIFT PLATE	|	HRS	1x8x10
18	31	1	SHAFT	|	AISI 4340	5 1/2 DIA. x 16
10	30	1	PILLOW BLOCK	|	BOSTON #06926-6H ●	
10	29	1	WORM GEAR	6-2	BOSTON #GB 8100 ●	
27	28	4	INDEX ASSY.	2-2		
	27	4	SUPPORT ASSY.	|		
18	26	4	PLATE	|	HRS	1x6x12
18	25	2	PLATE	|	HRS	1x6x16
1/10	24	1/1	PILLOW BLOCK	|	BOSTON #06894-12H ●	
18	23	1	SHAFT	|	AISI 4340	5 1/2 DIA x 10
1	22	1	CLAMP	2-2	HRS	1 1/4 x 6 x 7
1/10	21	1/1	LEG	2	XHVY STL. PIPE	5x30
1/10	20	1/1	CROSS BAR	|	XHVY STL. PIPE	5x84
18	19	8	FRAME MEMBER	|	XHVY STL. PIPE	5x56
	18	1	TANK SUPPORT ASSY.	|		
18	17	4	LIFT LUG	|	HRS	3/4 x 4 x 5
1	16	1	PLATE	|	HRS	1x8x0
1	15	1	LIFT PLATE	|	HRS	1x5x8
1/10	14	1/1	COLUMN	2	X HVY STL. PIPE	5x70
18	13	8	PLATE	4	HRS	1/2 x 2 x 4
	12	4	BRACE	|	ANG. AL. 6061-T6	2x2x 1/4 x 71
7	11	4	PLATE	|	AL. 6061-T651	1/2 x 2 x 4
	10	1	STAND ASSY.	|		
10	9	2	CASTER (SWIVEL-BRAKE)	4	ALBION #62-PY-05201-WB1 ●	
7	8	2	CHANNEL	3	AL 6061-T6	6x3# x 136
	7	2	TIE ASSY.	3		
1/10	6	1/1	CASTER (SWIVEL)	2	ALBION #62-PY-05201 ●	
1/10	5	3/3	BRACE	|	BLK. STL. PIPE	1 1/2 x 40
1/10	4	2/2	PLATE	|	HRS	3/4 x 4 x 7
1	3	2	CASTER (RIGID)	|	ALBION #62-PY-05201-R ●	
1/10	2	3/3	PLATE	|	HRS	3/4 x 6 x 7
	1	1	STAND ASS'Y.	2		

SCALE 1/8 & NOTED
ALL DIMENSIONS IN INCHES

FLOOR AREA 150 SQ FT
APPROX WT 2800#

5-71695-5560
265540

DESIGN BY F. [illegible]

FINISH 2 — COLOR OF PROTECTIVE
TEST
DRAWING SHEET SIZE 21

TOOL DRAWING
THE BOEING COMPANY
AEROSPACE DIVISION

MISCELLANEOUS TOOL - HALF SCALE LH_2 TEST MODEL ASSY.

EMIT R5183 SHEET 1 OF 3

EMIT R5183 SHEET 1

Figure D-40

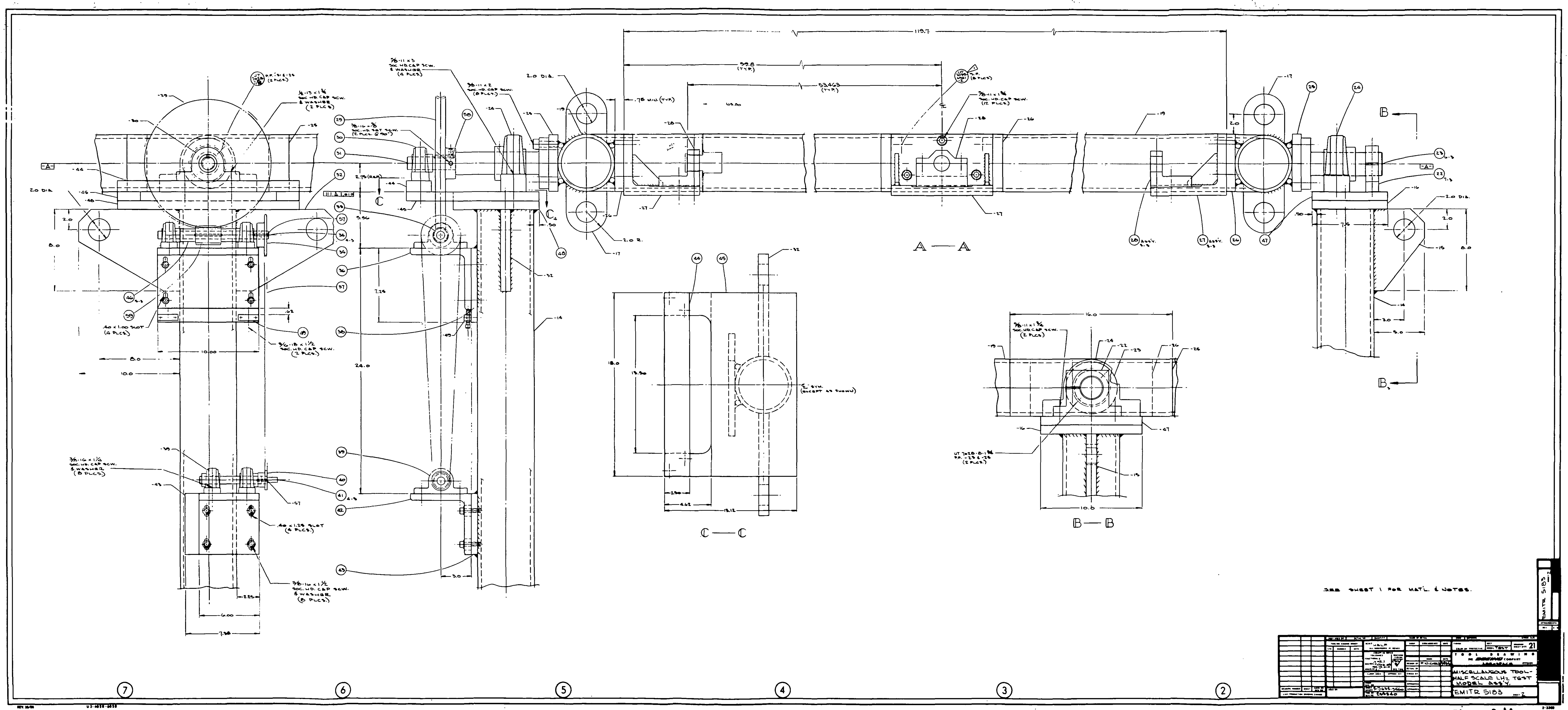
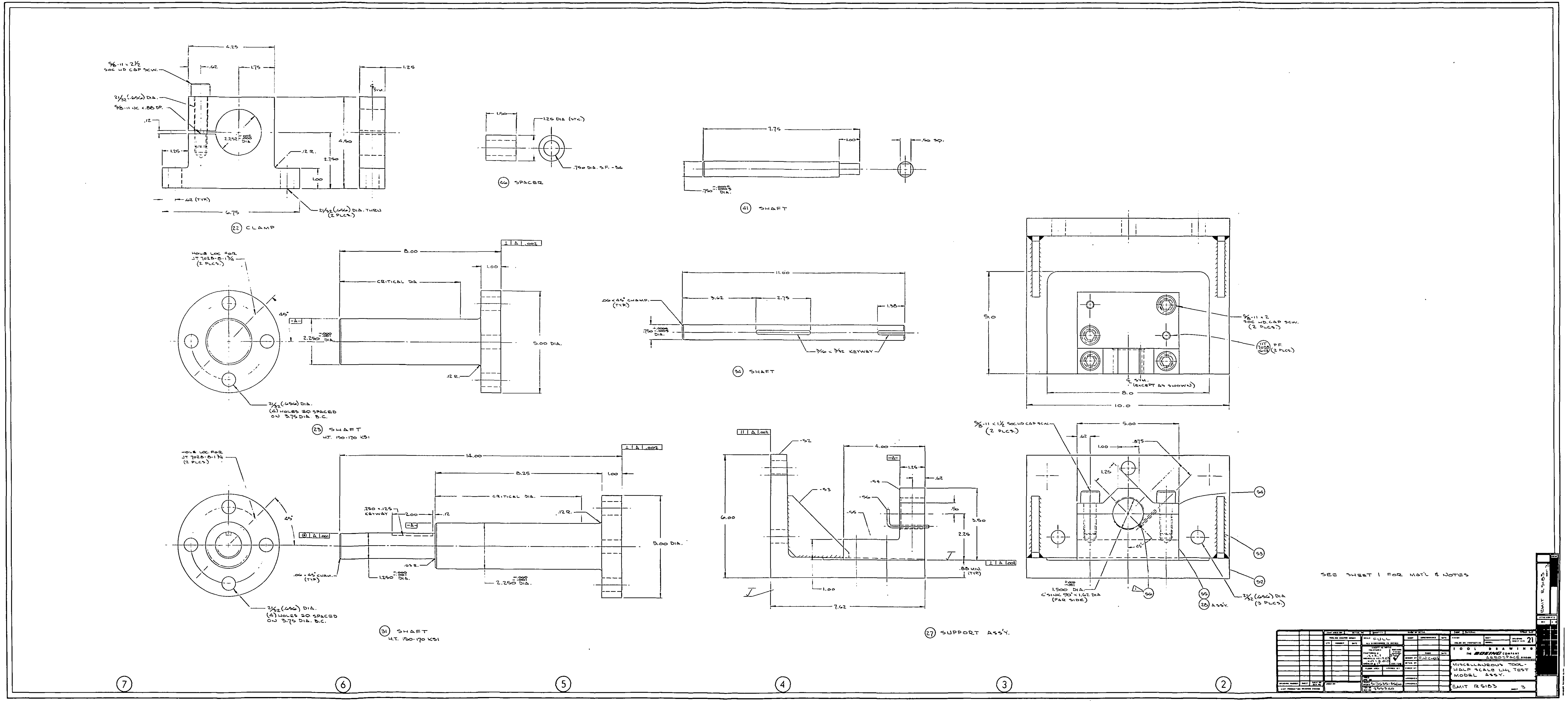

119.7
59.8 (TYP.)
53.463 (TYP.)
2.0 DIA.
2.0 R.
A — A
B — B
C — C
16.0
18.0
13.50
10.0
10.00
8.0
24.0
7.24
6.00
7.38
4.62
2.50
13.12
SEE SHEET 1 FOR MAT'L. & NOTES.
SCALE HALF
TOOL DRAWING
COMPANY
AEROSPACE
TEST
21
MISCELLANEOUS TOOL-
HALF SCALE LH2 TEST
MODEL ASS'Y.
EMITR 5183
SHEET 2
7
6
5
4
3
2

Figure B-41



86

Figure D-42

APPENDIX E

<u>THERMAL INSTRUMENTATION TEST PLAN</u>

<u>FOR THE LH_2 TEST MODEL</u>

APPENDIX E
THERMAL INSTRUMENTATION TEST PLAN FOR THE LH_2 TEST MODEL

The thermal instrumentation plan was developed from the Contract NAS 3-15848 Statement of Work instrumentation requirements. Thermocouple locations and wire routing are shown in Appendix D, Figures D-22 through D-26.

Table E-1 is a list of all thermocouples. The thermocouple entries in the list are grouped by the type of wire required and the lengths shown were used in determination of total quantities of wire required for the test. Four types of wire were used: Teflon insulated Chromel-Constantan for thermocouples in the evacuated volume; fiberglass insulated Chromel-Constantan for exterior locations; vinyl insulation Chromel-Constantan for hydrogen filled spaces; and vinly insulated copper wire for LH_2 reference junctions and leads. The computations for required wire lengths included added length margins to facilitate component assembly and disassembly.

Table E-2 lists those thermocouples which comply with the Statement of Work requirements. In some of the areas specified, a greater number of thermocouples than the minimum required were installed; also, a number of thermocouples were installed in areas not mentioned in the reference.

A practical limitation on the number of thermocouples located in the evacuated volume exists by virtue of the available space and cost for vacuum tight connectors. Four Deutsch Series DM-5623 connectors, located in the cover plate of the simulated plumbing penetration assembly housing, as shown in Figure D-38 was used. These connectors contain 37 contracts each, providing circuit connectors for 74 thermo-couples. These 74 thermocouples are listed as the first group in Table E-1.

The Deutsch connectors incorporate 18 Constantan and 19 Chromel pins each. Therefore, of the 74 thermocouples, 2 thermocouple circuits must use Chromel pins to connect their Constantan lead wires. Any temperature differences between the resulting superfluous Chromel-Constantan junctions will generate extraneous voltages, causing errors in the indicated temperatures. In order to minimize these possible errors, thermocouples in high temperature areas, i.e., thermocouples whose unaltered output voltage will be relatively high, were selected for routing through the all-Chromel connector pins. These thermocouples are T59 and T60 on the inner surface of the vacuum jacket. Any of the other thermcouples on this surface would have been suitable, except T56 or T62, for which accuracy is somewhat more important due to their association with thermocouple sets in the MIL.

Three thermocouples, T72, T73, and T74 were to be immersed in the GH_2 boil-off flow in the vent tube in an attempt to measure the temperature rise in the gas as it travels up the tube. The possibility of bonding small fins to these junctions to increase their response to changes in gas temperature was explored. Because of the need for maximum accuracy for these temperatures, relative to the saturated vapor temperature, these thermocouple circuits were to employ reference junctions within the LH_2 in the test tank rather than reference junctions in the cold box like all other thermocouples.

Thermocouple locations and wire routings were planned to achieve the best combination of accurate, useful data and minimum disruption. In some areas, these requirements conflicted and compromises were necessary. All thermocouples on or within the MLI were attached to shield layers with an aluminized Mylar tape having reflective properties very close to those of the shields themselves. When possible, the first 6 inches of wire leading to the thermocouple junction followed expected isotherm contours in order to minimize errors due to heat flow in the wires. On tubular components and support straps, loads made at least 2 turns around the component being routed away from the location of the junction.

Location and routings were planned to minimize junction and wire overlaps, avoding the MLI thickness disruption that would result from excessive superposition. This is the reason for the rosette patterns for thermocouples T1 through T6, T7 through T12, and T25 through T30, and the staggering of groups T13 through T18 and T19 through T24.

THERMOCOUPLE LIST

T/C IDENT.	COMPONENT		LOCATION ON COMPONENT		WIRE TYPE	LENGTH "A" (in)	LENGTH "B" (in)	LENGTH " " (in)	NOTES		
T1	MLI PANEL	-17	SHIELD	14	CHR-CON, TEFLON	151.7	187.7		(1)	(2)	(3)
T2			↓	28		148.7	184.7		(1)		
T3		↓	OUT. SURF.			138.7	174.7				
T4		-30	SHIELD	14		165.4	201.4		(1)		
T5		↓	↓	28		169.4	205.4		(1)		
T6		↓	OUT. SURF.			153.7	189.7				
T7		-10	SHIELD	14		78.0	114.0		(1)		
T8		↓	↓	28		74.0	110.0		(1)		
T9		↓	OUT. SURF.			64.9	100.9				
T10		-23	SHIELD	14		91.6	127.6		(1)		
T11		↓	↓	28		95.6	131.6		(1)		
T12		↓	OUT SURF.			80.0	116.0				
T13		-35	SHIELD	14		111.6	147.6		(1)		
T14		↓	↓	28		116.6	152.6		(1)		
T15		↓	OUT. SURF.			110.5	146.5				
T16		-10	SHIELD	14		108.4	144.4		(1)		
T17		↓	↓	28		111.5	147.5		(1)		
T18		↓	OUT. SURF.			109.0	145.0				
T19		-9	OUT. SURF.			86.9	122.9				
T20			SHIELD	28		94.4	130.4		(1)		
T21	↓	↓	↓	14		95.4	131.4		(1)		
T22	LOWER TENSION STRAP		℄, OUT. SURF.			104.3	140.3				
T23	MLI PANEL	-23	SHIELD	28	↓	99.4	135.4		(1)	↓	↓

	INITIALS	DATE	REV. BY INITIALS	DATE	TITLE	MODEL
CALC					TABLE E-1	
CHECK						
APPD						
APPD						

REV LTR ______

BOEING NO. SH.

THERMOCOUPLE LIST

T/C IDENT.	COMPONENT		LOCATION ON COMPONENT		WIRE TYPE	LENGTH "A"	LENGTH "B"	LENGTH " "	NOTES		
						(in)	(in)	(in)			
T 24	MLI PANEL	-23	SHIELD	14	CHR-CON, TEFLON	98.4	134.4		1	2	3
T 25		-8	OUT. SURF.			29.5	65.5				
T 26			SHIELD	28		42.0	78.0		1		
T 27				14		41.6	77.6		1		
T 28		-6	OUT. SURF.			39.5	75.5				
T 29			SHIELD	28		39.7	75.7		1		
T 30				14		40.8	76.8		1		
T 31	LOWER TENSION	STRAP	℄, OUT. SURF.			105.8	141.8				
T 32						102.8	138.8				
T 33						101.3	137.3				
T 34						99.8	135.8				
T 35	UPPER TENSION	STRAP				121.6	157.6				
T 36						120.1	156.1				
T 37						118.6	154.6				
T 38						117.1	153.1				
T 39						115.6	151.6				
T 42	GIRTH	RING	IN. SURF.			94.8	130.8				
T 43						94.8	130.8				
T 56	VAC. JACKET UPPER	HEAD	IN. SURF., OVER	TI-T6		137.2	173.2				
T 57			IN. SURF., 60° FROM T56			137.2	173.2				
T 58			IN. SURF. 120° FROM T56			137.2	173.2				
T 59			IN. SURF., 180° FROM T56			137.2	173.2				
T 60			IN. SURF., 240° FROM T56			137.2	173.2				

	INITIALS	DATE	REV. BY INITIALS	DATE	TITLE	MODEL
CALC					TABLE-E1	
CHECK						
APPD						
APPD						

REV LTR ______ BOEING NO. ______

THERMOCOUPLE LIST

T/C IDENT.	COMPONENT		LOCATION ON COMPONENT	WIRE TYPE	LENGTH "A" (in)	LENGTH "B" (in)	LENGTH " " (in)	NOTES		
T61	T/C JACKET UPPER HEAD		IN. SURF., 300° FROM T56	CHR-CON. TEFLON	137.2	173.2			2	3
T62	VAC JACKET LOWER HEAD		IN. SURF., OVER T7-T12		57.9	93.9				
T63			IN. SURF., 60° FROM T62		57.9	93.9				
T64			IN. SURF., 120° FROM T62		57.9	93.9				
T65			IN. SURF., 180° FROM T62		57.9	93.9				
T66			IN. SURF., 240° FROM T62		57.9	93.9				
T67			IN. SURF., 300° FROM T62		57.9	93.9				
T68	MLI PANEL	-7	SHIELD 34		182.7	218.7		1		
T69	INLET TUBE		OUT. SURF.		209.3	245.3				
T70					205.3	241.3				
T71					201.3	237.3				
T75	SIM. PLUMB. TUBE		OUT. SURF.		16.8	52.8				
T76					15.3	51.3				
T77					13.8	49.8				
T78	SIM. PLUMB. ASSY		END OF FG INS. RETAINER		16.0	52.0				
T86			TUBE INSUL. OUT. SURF		30.6	66.6				
T87					29.1	65.1				
T88					27.6	63.6				
T89	MLI PANEL	-6	OUT. SURF.		40.3	76.3				
T90		-8			23.3	59.3				
T91		-6			36.3	72.6				
T92		-8			27.3	63.6				
T96	PRESS. VESSEL	OUT. SURF.	UNDER T68		182.7	218.7				

	INITIALS	DATE	REV. BY INITIALS	DATE	TITLE	MODEL
CALC					TABLE-E1	
CHECK						
APPD						
APPD						

THERMOCOUPLE LIST

T/C IDENT.	COMPONENT		LOCATION ON COMPONENT		WIRE TYPE	LENGTH "A"	LENGTH "B"	LENGTH " "	NOTES		
						(in)	(in)	(in)			
T97	MLI PANEL	-9	OUT. SURF.		CHR-CON, TEFLON	83.2	119.2			2 3	
T98		-9				81.3	117.3				
T99		-23				92.9	128.9				
T102	PRESS. VESSEL OUT. SURF.		UNDER T1-T6			167.4	203.4				
T103			UNDER T7-T12			93.6	129.6				
T											
T											
TOTAL, 74 T/C IN VACUUM SPACE:						7030.2	9694.2				
T						=585.25'	=807.85'				
T											
TOTAL CHR-CON, TEFLON WIRE REQ'D:							808'				
T											
T											
T											
T											
T											
T											
T											
T											
T											
T											
T											
T											

	INITIALS	DATE	REV. BY INITIALS	DATE	TITLE	MODEL
CALC					TABLE-E1	
CHECK						
APPD						
APPD						

REV LTR ______ BOEING NO. ______ 98

SH. ______

THERMOCOUPLE LIST

T/C IDENT.	COMPONENT		LOCATION ON COMPONENT		WIRE TYPE	LENGTH "G" (in)	LENGTH "H" (in)	LENGTH " " (in)	NOTES		
T 40	GIRTH RING		OUT. SURF.		CHR-CON, VINYL	96.1	246.1			(8) (9)	
T 41	↓		↓			96.1	246.1				
T 44	VAC. JACKET UPPER HEAD		OUT. SURF. OVER T1-T6			139.2	289.2				
T 45			OUT SURF. 60° FROM T44			139.2	289.2				
T 46			OUT SURF. 120° FROM T44			139.2	289.2				
T 47			OUT SURF. 180° FROM T44			139.2	289.2				
T 48			OUT. SURF. 240° FROM T44			139.2	289.2				
T 49	↓		OUT. SURF. 300° FROM T44			139.2	289.2				
T 50	VAC. JACKET LOWER HEAD		OUT. SURF. OVER T7-T12			59.0	209.0				
T 51			OUT. SURF. 60° FROM T50			59.0	209.0				
T 52			OUT. SURF. 120° FROM T50			59.0	209.0				
T 53			OUT. SURF. 180° FROM T50			59.0	209.0				
T 54			OUT. SURF. 240° FROM T50			59.0	209.0				
T 55	↓		OUT. SURF. 300° FROM T50			59.0	209.0				
T 79	SIM. PLUMB. ASSY.		HOUSING CLOSEOUT PLATE			0.	150.0				
T 80	VAC. JACKET UPPER HEAD		NEAR VENT SAME MERIDIAN			187.0	337.0				
T 81	↓		AS T68, T96			182.0	332.0				
T 82	VENT HOUSING		CLOSEOUT EXTENSION			225.3	375.3				
T 83	SIM. PLUMB. ASSY.		HOUSING BASE FLANGE OUT. SURF.			17.2	167.2				
T 100	VAC. JACKET LOWER HEAD		NEAR SIM. PLUMB. PENETRATION			21.2	171.2				
T 101	↓		SAME MERIDIAN AS T91, T92		↓	26.7	176.7			↓	↓
TOTAL,	21 T/C ON ASSEMBLY EXTERIOR:					2040.8	5190.8				
T						=170.07	=432.6				

	INITIALS	DATE	REV. BY INITIALS	DATE	TITLE	MODEL
CALC					TABLE - E1	
CHECK						
APPD						
APPD						

REV LTR ______

BOEING | NO. | 1

THERMOCOUPLE LIST

T/C IDENT.	COMPONENT	LOCATION ON COMPONENT	WIRE TYPE	LENGTH "D" (in)	LENGTH "E" (in)	LENGTH " " (in)	NOTES		
T72	VENT TUBE	FREE STANDING IN VENT GAS	CHR-CON, VINYL	10.0	16.0		5	6	10
T73				20.0	26.0				
T74				29.0	35.0				
T93	FILL LINE	OUT. SURF., IN VENT TUBE		28.5	34.5				
T94				24.5	30.5				
T95				20.5	26.5				
T									
TOTAL,	6 T/C IN H_2 VENT SPACE :			132.5	168.5				
T				=11.04'	=14.04'				
T									
T									
T	EXTENSION WIRE FOR T/C's				LENGTH "C"				
T	IN VACUUM SPACE, EA.:				150.0		4		
TOTAL	EXT. WIRE, 74 T/C's :				11100.0				
T					=925.0'				
T									
T									
TOTAL	CHR-CON, VINYL WIRE REQ'D:								
T	FOR 21 EXTERIOR T/C's					432.6'			
T	FOR EXTENSIONS FOR 74 VAC. T/C's:					925.0'			
T	FOR 6 T/C's IN H_2 VENT SPACE :					14.0'			
T						1371.6'			
T									

	INITIALS	DATE	REV. BY INITIALS	DATE	TITLE	MODEL
CALC					TABLE-E1	
CHECK						
APPD						
APPD						

THERMOCOUPLE LIST

T/C IDENT.	COMPONENT		LOCATION ON COMPONENT		WIRE TYPE	LENGTH "J" (in)	LENGTH "K" (in)	LENGTH " " (in)	NOTES		
TREF72			IMMERSED		Cu	63.6	69.6		(10) (11)	(12)	
TREF73			IN LH_2,			63.6	69.6				
TREF74			10" BELOW			63.6	69.6				
TREF93			PRESS. VESSEL			63.6	69.6				
TREF94			VENT OUTLET			63.6	69.6				
TREF95			↓			63.6	69.6				
T											
TOTAL	, 6 REF. JUNCTION LEADS						417.6				
T							=34.8'				
T											
T							LENGTH "F"				
T	EXTENSION WIRE FOR REF.										
T	JUNCTION LEADS, EA:						310.0		(7)	(10)	
TOTAL	, CU EXTENSION WIRE						1860.0				
T							=155.0'				
T											
T											
TOTAL	, CU WIRE REQ'D:						34.8'				
T							155.0'				
T							189.8'				
T											
T											
T											

	INITIALS	DATE	REV. BY INITIALS	DATE	TITLE	MODEL
CALC					TABLE - E1	
CHECK						
APPD						
APPD						

REV LTR ______

BOEING NO. SH.

U3 4040 9000 REV. 6/64

THERMOCOUPLE LIST NOTES

(1) Shields are numbered counting from inner surface.

(2) Length "A" is calculated min. length from T/C to Deutsch vacuum-tight connectors on closure plate of simulated plumbing housing at bottom of vac. jacket.

(3) Length "B" = Length "A" plus 36.0".

(4) Length "C" is length of extension required from Deutsch connectors to terminals at reference box.

(5) Length "D" is calculated min. length of Chromel-Constantan wire from T/C to reference junction in LH_2.

(6) Length "E" = Length "D" plus 6.0".

(7) Length "F" = Length of Cu wire extension from H_2-tight connector on vent plenum to terminals at reference box.

(8) Length "G" is calculated length from T/C to plane of closure plate of simulated plumbing housing at bottom of vac. jacket.

(9) Length "H" = Length "G" plus 150.0 in. additional required from plane of closure plate to terminals at reference box.

(10) To be installed by Tulalip Test Site personnel.

(11) Length "J" is calculated min. length of Cu wire from reference junctions to H_2-tight connector.

(12) Length "K" = length "J" plus 6.0".

	INITIALS	DATE	REV BY INITIALS	DATE	TITLE	MODEL
CALC						
CHECK						
APPD.						
APPD.						

TABLE E-2

THERMOCOUPLE LOCATIONS FOR WORK STATEMENT COMPLIANCE

Work Statement Location Description	Thermocouples
"... six different depths in the MLI ... locations as follows:	
(a) Forward hemisphere on a line 45° from the centerline of the hemisphere.	T1,T2,T3,T4,T5,T6
(b) Aft hemisphere on a line 45° from the centerline of the hemisphere.	T7,T8,T9,T10,T11 T12
(c) Mid point of the cylindrical section.	T13,T14,T15,T16,T17,T18
(d) At a point where an inner tank support passes through the insulation at a constant radial distance from the support.	T19,T20,T21,T22 T23,T24
(e) The insulation within the simulated manhole access area."	T25,T26,T27,T28, T29,T30
"Twelve thermocouples ... on both the exterior of the vacuum jacket and the inner face shin of the vacuum jacket."	T44 through T55 T56 through T67
"Two thermocouples ... bonded to both exterior and interior surfaces of the girth ring."	T40,T41 T42,T43
"Two of the inner vessel supports ... (a minimum of four on each support)."	T31,T22,T32,T33,T34 T35,T36,T37,T38,T39
"The thermally modeled manhole and fluid line penetrations ... (a minimum of four on each penetration)."	T75,T76,T77,T78, T86,T87,T88: T69,T70,T71,T82, T93,T94,T95.
"The ullage gas temperature shall be measured at the outlet of the pressure vessel."	T72

APPENDIX F

SYSTEM EVALUATION TEST PLAN

Revised: 1-17-74
5-31-74

TEST PLAN

LIGHTWEIGHT VACUUM JACKET FOR CRYOGENIC INSULATION

Distribution:	J. Allbee	4-1720	1E-11
	D. Barclay	2-5520	8C-45
	R. Hanna	2-5610	86-09
	R. Lominick	2-2405	1E-11
	F. Olsen	2-1833	4A-20

Test Engineer: H. M. Olden (signed) Date: 11-12-73
H. M. Olden

Test Supervisor: W. A. Smith (signed) Date: 11/12/73
W. A. Smith

TTS Test No.: 7308

Test Title: Lightweight Vacuum Jacket for Cryogenic Insulation

Contract No.: NASA Contract NAS3-15848

Test Location: Area 41, Pad 3

Reference:
(1) Procedures Manual, Tulalip Test Site, D2-121703-1

(2) Engineering Laboratories Safety Manual, D2-121354-1

(3) SOP- 72K

(4) Engineering Laboratories Test Practices Manual, D180-14822-1

(5) EWA No. 25540, Task IV

1.0 PURPOSE

The purpose of this test is to demonstrate system performance of a half scale model of the Shuttle Orbiter OMS fuel tank with an evacuated multi-layer insulation (MLI) system. The performance of this system will be carefully evaluated in conjunction with the rigorous cyclic operational requirements of the orbiter.

This test plan describes in sufficient detail the test conditions, instrumentation, facilities, equipment, and safety and operating procedures to insure meeting the program test objectives in a safe and efficient manner.

2.0 OBJECTIVE

Testing to be accomplished under this test plan will furnish data that will be used to verify the feasibility of the evacuated MLI system design for the OMS fuel tank.

3.0 SCOPE

A half scale model of the Shuttle Orbiter OMS fuel tank will be designed, fabricated and shipped to Tulalip Test Site for testing on Pad 3, Area 41. The tank will be installed into an existing LH_2 supply, vent and disposal system with some modifications required. A radiant heat shroud will be fabricated and installed around the tank to provide temperature conditioning. A boiloff test system will be assembled and installed for determining heat flow into the tank. Three boiloff tests will be performed. The first one will be considered the baseline boil off rate. The second one will be performed after subjecting the tank to 100 external pressure cycles of 0 to 200,000 ft. equivalent altitude pressure and 100 thermal cycles of 100 to 350°F. The third boiloff test will be conducted while simulating a specified hydrogen leak into the vacuum annulus of the tanks insulation system. The test data will provide information to determine if any degradation in performance of the insulation system has occurred as a result of these operational environments.

4.0 TEST CONDITIONS

4.1 There will be three boiloff tests and two cyclic tests performed under this test plan in the sequence as follows:

- Baseline boil-off test
- Load cycling (altitude cycling) test - Area 34
- Thermal cycling test
- Post cycling boil-off test
- Constant GH_2 leak boil-off test.

4.2 The test conditions for the three boiloff tests will be as follows:

• Tank internal pressure	17.0 PSIA
• Tank vacuum annulus pressure	$\leq 2.0 \times 10^{-4}$ Torr
• Tank external pressure	ambient
• Tank external temperature	$100°F \pm 5°F$
• Tank liquid hydrogen level	$<$3.0 in. from Top

4.3 The test conditions for the load cycling (altitude cycling) test will be as follows:

• Tank internal pressure	Same as external
• Tank vacuum annulus pressure	$<2.0 \times 10^{-4}$ Torr
• Tank external pressure	ambient to 1.6×10^{-1} Torr
• Tank external temperature	ambient

4.3 continued

- Tank liquid hydrogen level — No hydrogen
- Number of cycles — 100 cycles

4.4 The test conditions for the thermal cycling test will be as follows:

- Tank internal pressure — 15.0 PSIA
- Tank vacuum annulus pressure — $< 2.0 \times 10^{-4}$ Torr
- Tank external pressure — ambient
- Tank external temperature — $100^{o}F$ to $350^{o}F$
- Tank liquid hydrogen level — $<$ 14.0 in. from bottom
- Number of cycles — 100 cycles

4.5 The half scale tank model will be constructed of two 90.0 inch diameter hemispheres connected to an 18.0 inch long cylindrical section. This tank will hold 2150 gallons of LH_2 when full. The inner vessel will have an operating pressure of 17.0 psia, a proof pressure of 40.0 psia, and a design burst pressure of 70.0 psia.

5.0 FACILITIES

All testing will be conducted at the Boeing Company's Tulalip Test Site located approximately 45 miles north of Boeing's main Plant II headquarters. This facility has several well developed permanent test areas designed to handle a wide variety of hazardous and high noise level type tests. The cryogenic structural test facility, Test Area 41, is one of these specialized areas and will be used for this program. This area is devoted to structural materials testing which involve hazardous environments. These environments involve cryogenic propellants such as LH_2, LO_2 and toxic propellants such as LF_2, N_2O_4 and Hydrazine.

In order to efficiently and safely handle this type of testing the area has three heavily reinforced concrete test cells dispersed on an arc located 130 ft. from the test control and data recording building. Each test pad is separated on this arc by 85 ft. Each pad has permanently installed wiring for remote control of the test setup and for remotely recording all test data. In addition, each pad has installed plumbing which provides He and N_2 pressurization and purge gases, plant air, water, and electrical power.

This facility has permanently installed LH_2 supply capacity of 14,000 gal. with a distribution and control system to each of the three test pads.

All testing for this program, except for altitude cycling at Area 34, will be performed on Pad 3 of Test Area 41.

6.0 TEST EQUIPMENT

A schematic of the test setup is shown in Figure F-1.

The LH_2 fill system will include a LH_2 conditioning cryostat mounted above the test tank. This vacuum insulated device will condition the LH_2 prior to entering the test tank so that the thermodynamic properties of the entering hydrogen are nearly the same as the hydrogen already in the test tank. This is to minimize the disturbance of thermal equilibrium during test tank refill operations. The pressure in this cryostat will be maintained at a constant differential pressure of 0.5 psi above the pressure in the test tank.

A radiant heat shroud will be fabricated and installed around the test tank so as to provide the required test tank external surface temperature. This shroud will be an aluminum sphere with quartz radiant heat lamps installed to the inside surface. Electrical power to the lamps will be regulated by a Research Incorporated ignitron electrical power control Unit. A closed loop temperature feedback system will be used to control the electrical power required to maintain the desired tank surface temperature. Redundant over-temperature safety circuits will be installed to prevent accidental overheating of the tank. Preheated gaseous nitrogen (GN_2) will be used as a purge gas between the shroud and the external surface of the tank. This will aid in obtaining the desired surface temperature with minimum radiant heating power and also will exclude air, minimizing the chances of ignition of hydrogen.

The test tank internal pressure control system will consist of a closed loop pressure feedback servo valve system. The servo valve will control the flow of hydrogen boiloff gas from the tank so that the desired pressure in the tank will be maintained at a constant value. An Annin globe valve with the proper sized trim and an electro-hydraulic actuator will be used as the servo valve. The tank pressure feedback will be measured with a Baratron differential pressure transducer referenced to a very stable constant pressure source. This high-resolution differential pressure transducer will be used to sense very small positive or negative pressure variations in the cryogenic tank relative to a constant reference pressure. This reference pressure source will be a fixed volume of gas maintained at a constant temperature in an ice bath. A set point controller will be used to sense the electrical output signal of the high-resolution differential pressure transducer for control of the electrohydraulic pressure regulating servo valve. This complete system results in controlling the tank pressure to a constant value with respect to the reference pressure.

The flowrate of the hydrogen boiloff gas will be measured with a Hastings-Radist HF series mass flowmeter calibrated per documented procedures prepared by the Boeing Cal.-Cert. laboratories. A copper tube heat exchanger will be used to maintain the hydrogen boiloff gas at a constant temperature before entering the pressure regulating valve and flowmeter. In addition, the entire tank pressure regulating and boiloff flow measuring system will be contained in an insulated constant temperature controlled environmental box for thermal stability purposes.

6.0 continued

The gaseous hydrogen (GH_2) leak system will consist of a needle valve, calibrated and installed to the test tank at the Kent Space Center, and a pure GH_2 pressure regulated supply system installed at Tulalip. The GH_2 leak rate needle valve will be calibrated at Kent by using helium leak rates corrected to yield the desired GH_2 leak rate. The calibrated leak will not be accessible when the LH_2 tank is loaded but final GH_2 leak rate adjustment will be provided by the remotely variable GH_2 supply pressure. Vacuum integrity will be insured by a remotely operated shut-off valve between the calibrated leak and the tank vacuum annulus. This valve will not be opened until the time of the constant GH_2 leak boil-off test. The section of plumbing between the calibrated leak and the vacuum shut-off valve will be evacuated prior to opening the annulus to the calibrated leak. This will purge this section of plumbing so as not to contaminate the tank annulus.

7.0 INSTRUMENTATION

An instrumentation list showing parameter, range, and accuracy is shown in Figure F-2. A block diagram of the instrumentation data acquisition system is shown in Figure F-3. All instrumentation equipment will have up-to-date calibration certifications issued by Boeing Quality Control Organization. These periodic calibrations are designated and performed per existing Q.C. documented standards. All calibrations are traceable to the National Bureau of Standards.

All pressures will be measured with strain gage pressure transducers. These will be located so that they will always be at ambient temperature thus requiring only an ambient calibration.

Test vessel temperatures above 0°F will be measured with chromel-constantan thermocouples with 150°F reference junction. Temperatures below 0°F will use a LN_2 reference junction. Temperatures measured in the vent tube will be set up as differential thermocouples with the LH_2 in the test tank as the reference temperature.

Hydrogen liquid level is determined by the use of carbon resistors which give a point indication as to the presence of liquid. In this application, the carbon resistor will be electrically driven so as to slightly heat up while in the presence of cold hydrogen gas. The increased heat dissipated as a result of submergence in the liquid hydrogen will cause a resistance change due to temperature which will be detected through a bridge circuit. This in turn will actuate a relay turning on an indicator light. The carbon resistor will be normally installed in a still-well (shield) to minimize false indications due to boiling liquid surface irregularities. Sufficient resistors will be installed in the test tank to adequately monitor liquid levels during thermal stabilization and boil-off testing. Power to carbon resistors will be turned off during R.
stability period when boil-off data is taken.

7.0 continued

The hydrogen boil-off gas flow rate will be measured with a Hastings-Radist, HF series, mass flowmeter. This will provide a continuous direct recording of mass flow rate from the tank. This meter with its laminar flow element will be calibrated per Boeing Cal-Cert laboratories documented procedures using hydrogen gas. The calibration will provide data as to actual standard cubic feet per minute of hydrogen gas vs millivolts output.

A MKS Baratron transducer will be used to monitor the pressure variations in the test tank. This device is a very high resolution differential pressure transducer which will be referenced to a stable constant pressure source.

The test tank vacuum annulus pressure will be monitored with the vac-ion pump current. The vac-ion pumps will be in continuous operation throughout the test program. A thermocouple gage and readout will be installed in the GH_2 leak system which could be opened to the annulus in case the annulus pressure increased beyond the effective range of the vac-ion pumps. This would provide an emergency means of monitoring the vacuum annulus pressure.

Test data will be recorded with a Non-Linear Systems (NLS) digital data recording system. This is a highly reliable, 200-channel recorder which records millivolt signal data on magnetic tape.that can be listed or plotted on IBM-compatible computers. The system is designed to operate continuously 24 hours per day, seven days per week. The sample rate is 10 samples per second. System accuracy is considered to be 40 microvolts of 100 millivolts full scale. The data tape will be removed from the recording system at the end of each boil-off test for computer processing. The data and calculated values will be tabulated and/or plotted as required for each boil-off test performed.

Some of the data parameters will be displayed and recorded on potentiometer type strip chart recorders. This will provide continuous quick-look information for ease in determining system stability and satisfactory performance.

A test progress report, consisting of the test log, reduced data, brief test summary of any test deviations or annomalies, and photographs will be prepared after each of the three boil-off tests.

8.0 TEST PROCEDURES

8.1 Lift test tank/fixture assembly from transportation trailer with crane and place it on Pad 3, Area 41. This assembly will remain as a complete unit throughout the Task IV test program.

8.2 Move test tank/fixture assembly into test position and connect to LH_2 fill and conditioning cryostat.

8.3 Connect vac-ion pump power to facility source and monitor annulus vacuum.

8.4 Connect tank thermocouples to test facility instrumentation wiring.

8.5 Leak check tank connection by pressurizing with gaseous helium and using a helium mass spectrometer to sniff joint.

8.6 Install four sections of the spherical heat shroud around test tank and connect all power and control cables.

8.7 Connect gaseous hydrogen supply to the calibrated leak system, and purge system with gaseous hydrogen. R

8.8 Adjust all the test tank and cryogenic system instrumentation recorders for their proper zeros and calibration pulses with the system vent valves VH 351 and VH 354 open.

8.9 Purge LH_2 conditioning cryostat by flowing helium through VHe 303 and out VH 354 for 2 min.

8.10 Purge test tank by continuing flow as in 8.9 but open VH 363 and VH 351 and close VH 354 causing helium flow out the vent for 20 min.

8.11 While purging, set up thermal conditions by gradually energizing the heat shroud radiant lamps and nitrogen gas flow to slowly increase vacuum jacket external temperature to $100^{\circ}F \pm 5^{\circ}F$. Monitor vacuum annulus pressure while temperature is being increased and for a period of time after reaching final temperature until pressure is stable or decreasing. If vacuum annulus pressure exceeds 2.0×10^{-4} Torr discontinue temperature increase until pressure decreases. If vacuum annulus external surface temperature of $100^{\circ}F \pm 5^{\circ}F$ cannot be reached without exceeding annulus pressure of 2.0×10^{-4} Torr, hold temperature at intermediate level until after completing tank LH_2 fill in paragraph 8.17.

8.12 Turn Pad 3 area condition lights to "RED" and notify Fire Department at completion of purging and after attaining external surface temperature conditions.

8.13 Set up the facility liquid hydrogen supply system per standard operating procedures for delivery of LH_2 to Pad 3.

8.14 Fill conditioning cryostat by opening vent VH 354 and pad LH_2 supply VH 301. The automatic liquid level control system will operate VH 301 as needed to maintain the cryostat full of LH_2.

8.15 Set conditioning cryostat pressure control VH 365 to automatic and close VH 354 which will hold its pressure to 17.5 psia.

8.16 Fill test tank by opening VH 351 and then slowly opening VH 363 keeping the test tank pressure below 17.0 psia.

8.17 Stop test tank fill by closing VH 363.

8.18 Monitor test tank vacuum annulus pressure during and after filling with LH_2. It should decrease during filling but should not be greater than 2.0×10^{-4} Torr. Complete temperature conditioning per para. 8.11.

8.19 Continue to refill test tank per 8.13 through 8.17 as tank liquid level decreases to 6.0 inches from top.

8.20 When time between refills approaches 6.0 hrs. then set VH 382 to automatic operation and close VH 351 which will hold test tank pressure at 17.0 psia.

8.21 Continue to monitor all data parameters and refilling tank per 8.19 until all data appears stabilized indicating thermal equilibrium has been obtained.

8.22 Boil-off data will be sampled at decreasing time intervals until considered stabilized for boil-off measurement data. At this time, 4 hrs of concentrated data will be taken. R

8.23 Stop conditioning cryostat fill by closing VH 301 and open vent VH 354 and drain VH 366.

8.24 Empty test tank by opening VH 363 and maintaining 17 to 20 psia in tank by closing VH 382 and intermittently opening helium purge valve VHE 352.

8.25 Test tank will be empty when LL1 light goes out and temperature TS1 begins to rise sharply.

8.26 Close VHE 352 and VH 363 and open VH 351. R

8.27 Empty conditioning cryostat by opening VH 366 and closing VH 354. It will be empty when LL9 light goes out and temperature TS2 begins rising.

8.28 Open VH 363 and close VH 366 and VH 354 to prepare system for helium purge and initial warmup. R

8.29 Open VHE 355 to purge system for 10 min. and then turn helium heater on to initiate system warmup.

8.30 When TS1 indicates -250°F switch purge gas supply from helium to nitrogen.

8.31 Continue gaseous nitrogen warmup until TS1 reaches 50°F. Then turn off heater and GN_2 and return test pad to green condition. Leave a slight positive pressure in system. R

8.32 Turn off radiant heat shroud and remove shroud from tank.

8.33 Disconnect instrumentation from test tank.

8.34 Disconnect vac-ion power from facility and put on portable supply.

8.35 Disconnect test tank/fixture assembly from conditioning cryostat and move out of test pad 3.

8.36 Load test tank/fixture assembly on transport trailer and move to Area 34 for altitude testing.

8.37 Lift test tank/fixture assembly from transport trailer at Area 34 and place on altitude chamber dolly.

8.38 Roll test tank/fixture assembly into altitude chamber and connect vac-ion pumps to facility power supply.

8.39 Close altitude chamber and evacuate to an equivalent altitude pressure of 200,000 ft. and return to ambient pressure.

8.40 Monitor test tank vacuum annulus pressure all during the pressure cycle. If the vacuum annulus pressure rises above the vac-ion pump capability R (approximately 2.4×10^{-4} Torr) the test will be stopped. Procedures to reactivate the test will be developed at that time.

8.41 Repeat this pressure cycle 100 times.

8.42 Open altitude chamber and remove test tank/fixture assembly for transport back to Area 41.

8.43 At Area 41 repeat steps 8.1 through 8.18 stopping test tank fill when liquid level reaches 14.0 inches from bottom of tank by closing VH 363.

8.44 Maintain this liquid level all during the succeeding thermal cycling test by opening VH 363 to refill test tank as needed. The thermal cycling will be interrupted during each refill operation.

8.45 Heating to 350°F must be approached cautiously. The possibility of outgassing beyond the pumping capability of the vac-ion pumps exists. Heating should be controlled so that when the limitation of the vac-ion pump ($\approx 2.4 \times 10^{-4}$ Torr) is approached the heating system is immediately shut off and R cold nitrogen gas is introduced in the shroud area to restrict further outgassing if possible. If the vacuum annulus pressure rises above the vac-ion pump capability, the test would be stopped. Procedures to reactivate the test would be developed at that time.

8.46 Slowly apply heat manually for the first 100°F to 350°F temperature cycle while observing the precautions of para. 8.45.

8.47 Turn heat shroud controller to thermal cycle programmer and automatically cycle test tank surface temperature from 100°F to 350°F for a total of 100 cycles. Continually monitor test tank vacuum annulus pressure for any signs of degradation or system failure.

8.48 At end of thermal cycle test return heat shroud control to set point of 100°F for the following post cycling boil-off test.

8.49 Perform the post cycling boil-off test as in Section 8.16 through 8.22.

8.50 Evacuate the GH_2 leak system by opening VV 360 and pumping until P_4 stabilizes in pressure.

8.51 Close VV 360 and open VV 357 which will meter a calibrated flow of hydrogen gas into the vacuum annulus.

8.52 Set hydrogen supply pressure regulator VH 386 so that P_3 is at a value TBD psia.

8.53 The flow rate of GH_2 leak gas will be trimmed by adjusting supply pressure, P_3. Gradually increase P_3 in steps, monitoring vacuum annulus pressure. Final P_3 setting will be that resulting in a stable vacuum annulus pressure of TBD Torr.

8.54 Perform the constant GH_2 leak boil-off test per section 8.19 through 8.23.

8.55 Close VV 357 to stop GH_2 leak into vacuum annulus. Continue to refill test tank with LH_2 per section 8.19 until vacuum annulus pressure returns to TBD Torr or for 3 days, whichever occurs first. Monitor vacuum annulus pressure. No boil-off rate or temperature data required.

8.56 Empty, purge and warm up test tank per 8.24 through 8.31.

8.57 Prepare tank for shipment per 8.32 through 8.35.

8.58 Load test tank/fixture assembly on transport trailer for shipment to the Kent Space Center.

9.0 SAFETY CONSIDERATIONS

The LH_2 system to be used for this test poses no abnormal safety problem. The majority of the equipment, i.e., transfer lines, cryostats, vents and valves have all been used in past testing for several years. This specific test configuration has been used in nearly identical form for two previous test programs. The major difference for this program is in the size of the test tank. This tank will hold 2,150 gal. (1,270 lbs.) of LH_2.

Due to the integrity of the tank design, i.e., design, proof and operating pressures, failure of the test tank is considered highly improbable as long as overpressure conditions do not occur. Therefore, redundant pressure safety devices will be installed on the test tank so that maximum pressures will not be exceeded. Also, the vent system of the test tank has been sized such that in the event the vacuum fails in the insulation annulus the resultant higher boil-off rate will not cause the tank pressure to exceed a safe value.

In order to minimize the possible ignition of hydrogen gas that may accidently be released, all spark producing equipment will either be explosion proof or be inert-gas purged. The space between the radiant heat lamp shroud and the external surface of the test tank will also be purged with nitrogen gas in order to eliminate any possible ignition in that area.

The radiant heat system will have a redundant temperature shutoff safety system. One system will be within the temperature control unit and the backup system will be a completely independent unit and will shut off all electrical power to the heating system in the event tank temperatures exceed a safe value.

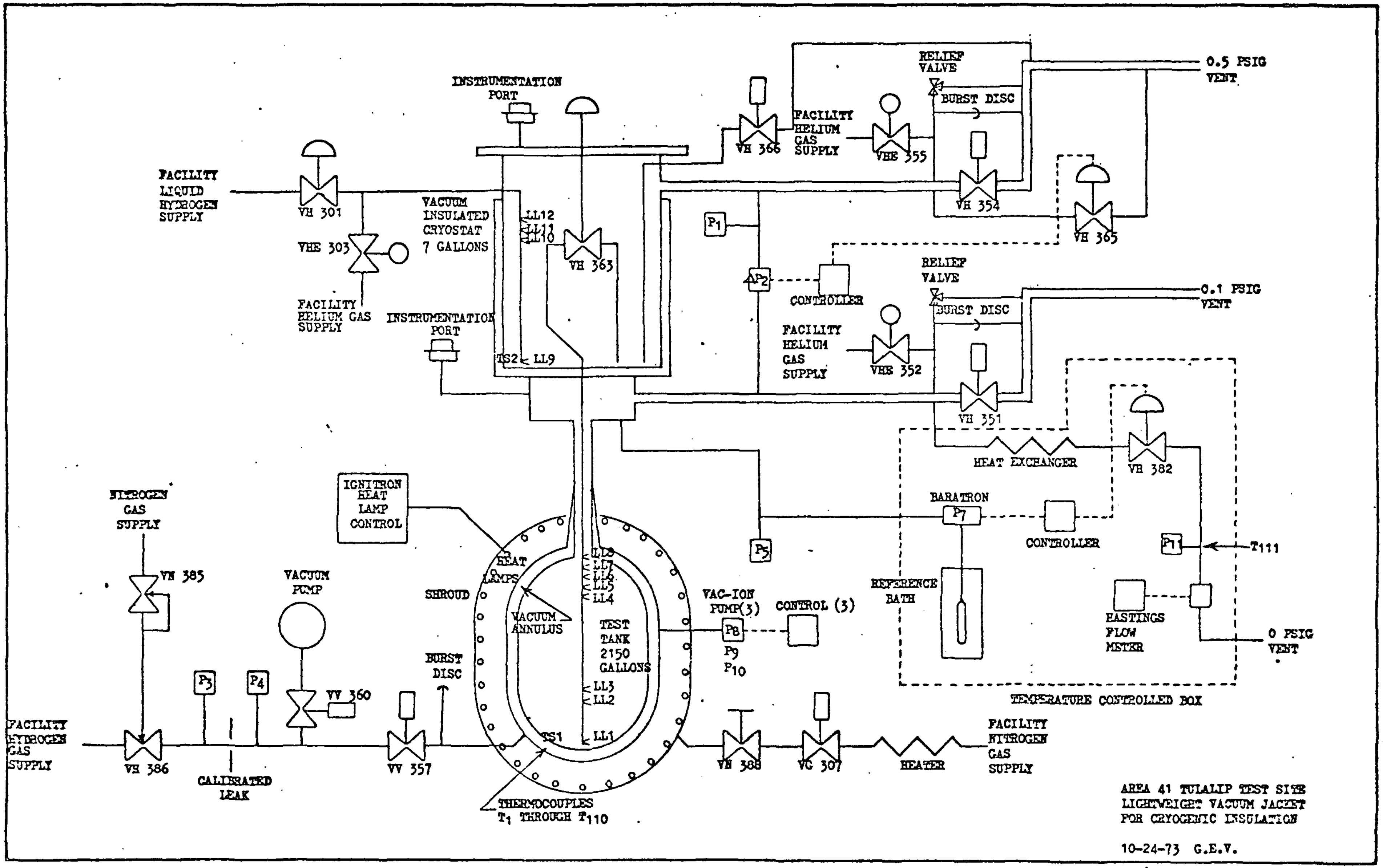
9.0 continued

In order to eliminate possible conflicts or confusion, and to increase the safety of operations, the assigned Test Area Engineer will have overall control of the test including safety procedures, cryogenic test procedures, malfunction procedures, and control of all personnel in the test area. During hydrogen test operations, all of the area of Test Area 41, east of the east end of the control house, will be excluded of all personnel.

10.0 MALFUNCTION PROCEDURES

A malfunction will be defined as any damage of equipment as a direct result of test operations conducted per this test plan. This could be caused by rupture and/or fire of/or from the test tank.

In the event of the above all hydrogen supply valves will be closed and the test tank will be emptied per 8.24 through 8.31, if possible, and the LH_2 conditioning cryostat emptied immediately after the test tank. The Fire Department will be notified and instructed to proceed to Test Area 41 and coordinate with the Test Area Engineer for further action. Helium purges of both tanks will then be turned on and maintained to warm up the test tanks and eliminate hydrogen. As soon as the hydrogen has been expelled and no over-pressurization of a tank exists the Fire Department may then be admitted to the pad area to expel any secondary fires that may exist and to cool down the test area. All main electrical power to the pad will also be turned off to eliminate electrical hazards. If a malfunction occurs the Test Area Engineer will immediately notify the Test Site Manager and the Ordnance Engineer. A written report will subsequently be prepared giving the details surrounding the incident. Corrective action will be taken before any further testing per this test plan is resumed.



REV LTR ________

BOEING | NO. FIGURE F-1 | Test No. 7308
Sh 12

PARAMETER			ACCURACY	RANGE		CALIBRATION			J-BOX	BALANCE PANEL	MAC PANEL	DATA SYSTEM CHAN	RECORDER CALIBRATION
DESCRIPTION	NUMBER	S/N		RATED	USING	%	DIV	PSI					
PRESSURE													
Cryostat	P_1		1% F.S.		5 psig								
Cryostat vs Test Tank	P_2		1% F.S.		5 psid								
Hydrogen Gas Supply	P_3		1% F.S.		50 psig								
Hydrogen Gas Vacuum	P_4		1% F.S.		$1x10^{-5}$ Torr								
Test Tank	P_5		1% F.S.		5 psig								
Barometric Pressure	P_6		1% Reading		0-15psia								
Test Tank vs Reference	P_7		±.0002psi		2 psid								
Vacuum Annulus	P_8		1% F.S.		$1x10^{-5}$ Torr								
Vac. Annulus " "	P_9 P_{10}		1% F.S. "		$1x10^{-5}$ Torr "								
TEMPERATURE													
Bottom Test Tank	TS 1		Indication		$-423^{\circ}F$								
Bottom Cryostat	TS 2		"		"								
LIQUID LEVEL													
Bottom Test Tank	LL 1		.1 Inch		On/Off								
10% Test Tank	LL 2												
10% Test Tank	LL 3												
Top Test Tank	LL 4												
Top Test Tank	LL 5												
Top Test Tank	LL 6												
Top Test Tank	LL 7												
Top Test Tank	LL 8												
Bottom Cryostat	LL 9												
Top Cryostat	LL 10												
Top Cryostat	LL 11												
Top Cryostat	LL 12		.1 Inch		On/Off								
FLOW METER			3% of Reading		2.5 SCFM								

	INITIALS	DATE	REV BY INITIALS	DATE	TITLE	MODEL
CALC.	GEV	10/26/			INSTRUMENTATION LIST AREA 41 LIGHTWEIGHT VACUUM JACKET FOR CRYOGENIC INSULATION	
CHECK						
APPD						
APPD						

REV LTR________

U3 4011 3000 REV. 2.65

BOEING NO. FIGURE F2- Test No. 7308

SH 13

114

PARAMETER			ACCURACY	RANGE		CALIBRATION		J-BOX	MAC PANEL	DATA SYSTEM CHAN	RECORDER CALIBRATION
DESCRIPTION	NUMBER					REFERENCE					
THERMOCOUPLE											
Surface &	T 1		± 2°F	-300 to	+350°F						
Buried MLI	T 2										
Upper Hemi	T 3										
	T 4										
	T 5										
	T 6										
Surface &	T 7		± 2°F	-300 to	+350°F						
Buried MLI	T 8										
Lower Hemi	T 9										
	T 10										
	T 11										
	T 12										
Surface &	T 13		± 2°F	-300 to	+350°F						
Buried MLI	T 14										
Blanket	T 15										
Girth	T 16										
	T 17										
	T 18										
Surface &	T 19		± 2°F	-300 to	+350°F						
Buried MLI	T 20										
Upper Strap	T 21										
	T 22										
	T 23										
	T 24										
Surface &	T 25		± 2°F	-300 to	+350°F						
Buried MLI	T 26										
Lower Polar	T 27										
Cap	T 28										
	T 29										
	T 30										

	INITIALS	DATE	REV BY INITIALS	DATE	TITLE	MODEL
CALC.	GLV	10/26/[illegible]			INSTRUMENTATION LIST AREA 41 LIGHTWEIGHT VACUUM JACKET FOR CRYOGENIC INSULATION	
CHECK						
APPD						
APPD						

REV LTR

U3 4011 3000 REV. 2/65

BOEING NO. FIGURE F-2 - Test No. 7308

SH 14

PARAMETER			ACCURACY	RANGE		CALIBRATION		J-BOX			MAC PANEL		DATA SYSTEM CHAN			RECORDER CALIBRATION			
DESCRIPTION	NUMBER					REFERENCE													
THERMOCOUPLE																			
Support Strap	T31		± 2°F	-300° to	+350°F														
	T32																		
	T33																		
	T34																		
Lower Strap	T35		± 2°F	-300° to	+350°F														
	T36																		
	T37																		
	T38																		
	T39																		
Surface Ex	T40		± 2°F	+60° to	+350°F														
Girth Ring	T41																		
Surface In	T42		± 2°F	+60° to	+350°F														
Girth Ring	T43																		
Vac Jac	T44		± 2°F	+60° to	+350°F														
Exterior	T45																		
	T46																		
	T47																		
	T48																		
	T49																		
	T50																		
	T51																		
	T52																		
	T53																		
	T54																		
	T55																		
Vac Jac	T56		± 2°F	+60° to	+350°F														
Interior	T57																		
	T58																		
	T59																		
	T60																		

	INITIALS	DATE	REV BY INITIALS	DATE	TITLE	MODEL
CALC.	GSV	10/26/6			INSTRUMENTATION LIST AREA 41 LIGHTWEIGHT VACUUM JACKET FOR CRYOGENIC INSULATION	
CHECK						
APPD						
APPD						

REV LTR______

U3 4011 2000 REV. 2/65

BOEING NO. FIGURE F-2 - Test No. 7308

SH 15

115.16

PARAMETER DESCRIPTION	NUMBER		ACCURACY	RANGE	CALIBRATION REFERENCE	J-BOX	MAC PANEL	DATA SYSTEM CHAN	RECORDER CALIBRATION
THERMOCOUPLES									
Vac Jac	T61		± 2°F	+60° to +350°F					
Interior	T62								
(Cont)	T63								
	T64								
	T65								
	T66								
↓	T67		↓	↓					
MLI Polar Cap	T68		± 2°F	0 to + 275°F					
Surface	T69		± 2°F	-423° to +32°F					
Vent Tube	T70								
↓	T71		↓	↓					
Vent Tube	T72		±.5°F	-423° to 0					
Space	T73		Relative						
↓	T74		↓	↓					
Surface Tube	T75		± 2°F	-423° to +100°F					
Sim Pen	T76								
	T77								
↓	T78		↓						
End Sim Pen	T79		± 2°F	+60° to +350°F					
Vac Jac	T80		± 2°F	+60° to +350°F					
Near Fill	T81		↓	↓					
Vent Line	T82		± 2°F	-423° to +32°F					
Surface Pen	T83		± 2°F	+60° to +350°F					
↓	T84		↓	↓					
MLI Pen	T86		± 2°F	-300° to +100°F					
	T87								
↓	T88		↓	↓					
MLI Surface	T89		± 2°F	-200° to +350°F					
↓	T90		↓	↓					

	INITIALS	DATE	REV BY INITIALS	DATE	TITLE	MODEL
CALC.	GEY	10/26/			INSTRUMENTATION LIST AREA 41 LIGHTWEIGHT VACUUM JACKET FOR CRYOGENIC INSULATION	
CHECK						
APPD						
APPD						

REV LTR________

U3 4011 3000 REV. 2/65

BOEING NO. FIGURE F-2 – Test No. 7308

SH 16

PARAMETER DESCRIPTION	NUMBER		ACCURACY	RANGE		CALIBRATION REFERENCE	J-BOX	MAG PANEL	DATA SYSTEM CHAN	RECORDER CALIBRATION
THERMOCOUPLE										
MLI Surface	T91		± 2°F	-200° to	+350°F					
↓	T92		↓	↓	↓					
Surface	T93		± 2°F	-423° to	+ 32°F					
Fill Line	T94		↓	↓	↓					
↓	T95									
Tank Surface	T96		± 2°F	-423° to	-200°F					
MLI Surface	T97		± 2°F	-200° to	+350°F					
Surface	T98		± 2°F	-200° to	+350°F					
↓	T99		↓	↓	↓					
Vac Jac	T100		± 2°F	+ 60° to	+350°F					
Outer Sur	T101		↓	↓	↓					
External	T102		± 2°F	-423° to	-200°F					
Surface	T103		↓	↓	↓					

	INITIALS	DATE	REV BY INITIALS	DATE
CALC.	GEV	10/26/		
CHECK				
APPD				
APPD				

TITLE: INSTRUMENTATION LIST AREA 41 LIGHTWEIGHT VACUUM JACKET FOR CRYOGENIC INSULATION

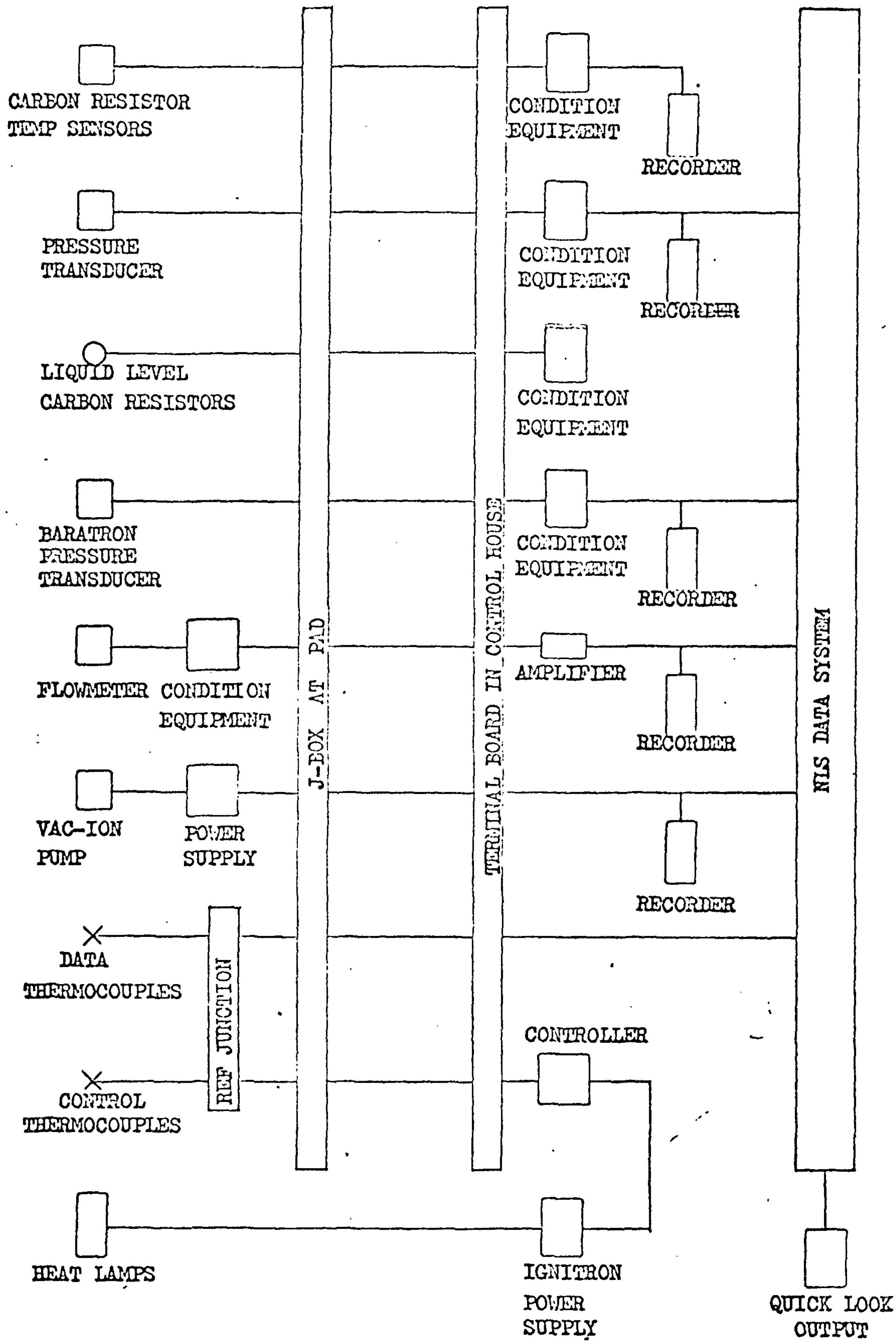
MODEL

REV LTR

U3 4011 3000 REV. 2/66

BOEING NO. FIGURE F-2 - Test 7308

SH 17



AREA 41 TULALIP TEST SITE
LIGHTWEIGHT VACUUM JACKET
FOR CRYOGENIC INSULATION

FIGURE F-3

NAS3-15848 DISTRIBUTION LIST FOR FINAL REPORT
"LIGHTWEIGHT VACUUM JACKET FOR CRYOGENIC INSULATION". VOL. I, NASA CR 134759; VOL. II, NASA CR 134760.

National Aeronautics & Space Administration
Lewis Research Center
21000 Brookpark Road
Cleveland, Ohio 44135

1	Attn:	Contracting Officer, MS 500-313
5		E. A. Bourke, MS 500-205
1		Technical Utilization Office, MS 3-16
1		Technical Report Control Office, MS 5-5
2		AFSC Liaison Office, MS 501-3
2		Library, MS 60-3
1		Office of Reliability & Quality Assurance, MS 500-211
3		J.R.Barber , Project Manager, MS 500- 203

National Aeronautics & Space Administration
Headquarters
Washington, D.C. 20546

	Attn:	Office of Aeronautics & Space Technology
1		Director, Manned Space Technology/RS
1		Director, Space Propulsion & Power/RP
1		Director, Materials & Structures/RW
1		F. W. Stephenson/RPI
	Attn:	Office of Manned Space Flight
1		Director, Advanced Manned Mission/MT
	Attn:	Office of Space Science
1		Director, Physics & Astronomy Programs/SG
1		Director, Planetary Programs/SL
1		Director, Launch Vehicles & Propulsion/SV
1	Attn:	Office of Technology Utilization Division
		Director, Technology Utilization/KT

1 National Aeronautics & Space Administration
Ames Research Center
Moffett Field, Calidfornia 94035
Attn: Library

1 National Aeronautics & Space Administration
Flight Research Center
P. O. Box 273
Edwards, California 93523

National Aeronautics & Space Administration
George C. Marshall Space Flight Center
Huntsville, Alabama 35912

1 Attn: Library
1 A. G. Orillion
1 T. W. Barret
1 J. M. Stuckey
1 I. G. Yates
1 E. H. Hyde

1 National Aeronautics & Space Administration
Goddard Space Flight Center
Greenbelt, Maryland 20771
Attn: Library

National Aeronautics & Space Administration
John F. Kennedy Space Center
Cocoa Beach, Florida 32931

1 Attn: Library

1 W. S. Brosier, LL-OPN-2

National Aeronautics & Space Administration
Lyndon B. Johnson Space Center
Houston, Texas 77001

1 Attn: Library
1 W. Chandler

National Aeronautics & Space Administration
Langley Research Center
Langley Station
Hampton, Virginia 23365

1 Attn: Library
1 I. O. MacConochie, MS411
1 C.D'Alutolo, MS 249A

10 NASA Scientific & Technical Information Facility
P. O. Box 8757
Baltimore/Washington International Airport
Baltimore, MD 21240
Attn: NASA Representative

1 Office of the Director of Defense
Research & Engineering
Washington, D. C. 20301
Attn: Office of Ass't Director(Chemical Technology)

Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, California 91103

1 Attn: Library 1 D. Dipprey
1 J. Kelly
1 R. Breshears

1 Defense Documentation Center
Cameron Station
Building 5
5010 Duke Street
Alexandria, Virginia 22314
Attn: TISIA

1 Advanced Research Projects Agency
Washington, D. C. 20525
Attn: Library

1 Aeronautical Systems Division
Air Force Systems Command
Wright-Patterson Air Force Base
Dayton, Ohio
Attn: Library

1 Air Force Missile Test Center
Patrick Air Force Base
Florida
Attn: Library

1 Air Force Systems Command
Andrews Air Force Base
Washington, D. C. 20332
Attn: Library

Air Force Rocket Propulsion Laboratory(RPR)
Edwards, California 93523

1 Attn: Library
1 R. L. Wiswell, LKDS

1 D. A. Hart

1 Air Force Rocket Propulsion Laboratory(RPM)
Edwards, California 93523
Attn: Library

1 Air Force FTC (FTAT-2)
Edwards Air Force Base
California 93523
Attn: Library

Air Force Office of Scientific Research
Washington, D. C. 20333

Attn: Library

1 U. S. Air Force
Washington, D. C.
Attn: Library

1 Air Force Aero Propulsion Laboratory
Research & Technology Division
Air Force Systems Command
U. S. Air Force
Wright-Patterson AFB, Ohio 45433
Attn: Library (APRP)

1 Arnold Engineering Development Center
Air Force Systems Command
Tullahoma, Tennessee
Attn: Library

Space & Missile Systems Organization
Air Force Unit Post Office
Los Angeles, California 90045

1 Attn: Library(Technical Data Center)

1 Office of Research Analyses(OAR)
Holloman Air Force Base
New Mexico 88330
Attn: Library (RRRD)

1 RTD (RTNP)
Bolling Air Force Base
Washington, D. C. 20332

1 Bureau of Naval Weapons
Department of the Navy
Washington, D. C.
Attn: Library

1 Naval Research Branch Office
1030 E. Green Street
Pasadena, California 91101
Attn: Library

1 Picatinny Arsenal
Dover, New Jersey 07801
Attn: Library

1 U.S. Naval Research Laboratory
Washington, D. C. 20390
Attn: Library

1 U. S. Army Research Office(Durham)
Box CM, Duke Station
Durham, North Carolina 27706
Attn: Library

1 U. S. Army Missile Command
Redstone Scientific Information Center
Redstone Arsenal, Alabama 35808
Attn: Document Section

1 U. S. Naval Missile Center
Point Mugu, California 93041
Attn: Technical Library

1 U. S. Naval Weapons Center
China Lake, California 93557
Attn: Library

1 Aerojet-General Corporation
Electronics Division
P. O. Box 296
Azusa, California 91703
Attn: Library

1 Aerojet-General Corporation
Space Division
9200 East Flair Drive
El Monte, California 91734
Attn: Library

1 Aerojet-General Corporation
Aerojet Ordance & Manufacturing
11711 South Woodruff Avenue
Fullerton, California 90241
Attn: Library

1 Aerojet Liquid Rocket Company
P. O. Box 15847
Sacramento, California 95813
Attn: Technical Library 2484-2015A

1 Aerospace Corporation
2400 E. El Segundo Blvd
Los Angeles, California 90045
Attn: Library
V. H. Monteil

1 Garrett Corporation
Airesearch Mfg. Division
9851 Sepulveda Blvd
Los Angeles, California
Attn: Library

1 Garrett Corporation
Airesearch Mfg. Division
402 South 36th Street
Phoenix, Arizona 85034
Attn: Library

1 Aro Incorporated
Arnold Engineering Development Center
Arnold AF Station, Tennessee 37389
Attn; Library

1 Battelle Memorial Institute
505 King Avenue
Columbus, Ohio 43201
Attn: Library

1 Beech Aircraft Corporation
Boulder Facility
Box 631
Boulder, Colorado

1 Bell Aerosystems Inc
Box 1
Buffalo, New York 14240

Attn: Library

1 Bendix Corporation
Instruments & Life Support Division
P. O. Box 4508
Davenport, Iowa 52808
Attn: Library

1 Booing Company
1625 K Street N. W.
Washington, D. C.

1 Boeing Company
P. O. Box 1680
Huntsville, Alabama 35801

1 Chemical Propulsion Information Agency
Applied Physics Laboratory
8621 Georgia Avenue
Silver Spring, Maryland 20910

1 Chrysler Corporation
Missile Division
P. O. Box 2628
Detroit, Michigan
Attn: Library

1 Chrysler Corporation
Space Division
P.O. Box 29200
New Orleans, Louisiana 70129
Attn: Library

1 Curtiss-Wright Corporation
Wright Aeronautical Division
Woodridge, New Jersey
Attn: Library

1 Denver Research Institute
University of Denver
P. O. Box 10127
Denver, Colorado 80210
Attn: Security Office

1 Fairchild Stratos Corporation
Aircraft Missile Division
Hagerstown, Maryland
Attn: Library

1 Fairchild Hiller Corporation
Research Center
Germantown, Maryland
Attn: Library

1 Fairchild Hiller Corporation
Republic Aviation
Farmington, L. I. N. Y.

General Dynamics/Convair
P. O. Box 1128
San Diego, California 92112

1 Attn: Library
1 R. Tatro

1 General Electric Company
Missiles & Space Systems Center
Valley Forge Space Technology Center
P. O. Box 8555
Philadelphia, Pennsylvania 19101
Attn: Library

1 General Electric Company
Apollo Support Department
P. O. Box 2500
Daytona Beach, Florida 32015
Attn: C. Bay

1 Grumman Aircraft Engineering Corporation
Bethpage, L. I. N.Y.
Attn: Library

1 Hamilton Standard Corporation
Windsor Locks, Conn. 06096
Attn: Library

1 Hercules Powder Company
Allegheny Ballistics Lab
P. O. Box 210
Cumberland, Maryland 21501
Attn: Library

1 Honeywell Inc.
Aerospace Division
2600 Ridgeway Road
Minneapolis, Minnesota
Attn: Library

1 IIT Research Institute
Technology Center
Chicago, Illinois 60616
Attn: Library

1 International Nickel Company
One New York Plaza
New York , N. Y. 10004
Attn: C. B. Sanborn

1 Kidde Aerospace Division
Walter Kidde & Company
567 Main Street
Belleville, New Jersey 07109
Attn: Library

1 Linde, Division of Union Carbide
P. O. Box 44
Tonawanda, N.Y. 11450
Attn: G. Nies

1 Ling-Temco-Vought Corporation
P. O. Box 5907
Dallas, Texas 75222
Attn: Library

Lockheed Missiles & Space Company
P. O. Box 504
Sunnyvale, California 94087

1 Attn: Library
1 R. T. Parmley

1 Lockheed Propulsion Company
P. O. Box 111
Redlands, California 92374
Attn: Library

1 Marquardt Corporation
16555 Saticoy Street
Box 2013 South Annex
Van Nuys, California 91409

Attn: Library

1 Minnesota Mining & Manufacturing Company
900 Bush Avenue
St. Paul, Minnesota 55106
Attn: Library

Martin-Marietta Corporation
P. O. Box 179
Denver, Colorado 80201

1 Attn: Library
1 G. C. Skartvedt

1 Martin-Marietta Corporation
Box 5827
Orlando, Florida
Attn: Library

1 McDonnell Douglas Astronautics
5301 Bosa Avenue
Huntington Beach, California 92647

1 Attn: Library
1 L. Q. Westmoreland
1 P. Klevatt

McDonnell Douglas Aircraft Corporation
P. O. Box 516
Lambert Field, Missouri 63166

1 Attn: Library
1 L. F. Kohrs

1 Northrop Space Laboratories
3401 West Broadway
Hawthorne, California
Attn: Library

1 Philco-Ford Corporation
Aeronutronic Division
Ford Road
Newport Beach, California 92663
Attn: Library

1 Purdue University
Lafayette, Indiana 47907
Attn: Library

1 Radio Corporation of America
Astro-Electronics Products
Princeton, New Jersey
Attn: Library

1 Rocketdyne
A Division of Rockwell International
6633 Canoga Avenue
Canoga Park, California 91304

Attn: Library

1 Space Division
A Division of Rockwell International
12214 Lakewood Blvd
Downey, California

Attn: Library

1 Rocket Research Corporation
Willow Road At 116th Street
Redmond, Washington 98052
Attn: Library

1 Stanford Research Institute
333 Ravenswood Avenue
Menlo Park, California 94025
Attn: Library

1 Susquehanna Corporation
Atlantic Research Division
Shirley Highway & Edsall Road
Alexandria, Virginia 22314
Attn: Library

1 Thiokol Chemical Corporation
Redstone Division
Huntsville, Alabama
Attn: Library

TRW Systems Inc.
1 Space Park
Redondo Beach, California 90278

1 Attn: Library
1 A. H. Zimmerman

1 TRW
TAPCO Division
23555 Euclid Avenue
Cleveland, Ohio 44117
Attn: Library

1 United Aircraft Corporation
Corporation Library
400 Main Street
East Hartford, Connecticut 06108

1 United Aircraft Corporation
United Technology Center
P. O. Box 358
Sunnyvale, California 94038
Attn: Library

United Aircraft Corporation
Pratt & Whitney Division
Florida Research & Development Center
P. O. Box 2691
West Palm Beach, Florida 33402

1 Attn: Library
1 G. B. Cox

1 Vickers Incorporated
Box 302
Troy, Michigan
Attn: Library

1 Vought Astronautics
Box 5907
Dallas, Texas
Attn: Library